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SIXTH ANNUAL REPORT

OF THE

Agricultural Experiment Station

OF THE

UNIVERSITY OF WISCONSIN,

FOR THE YEAR ENDING JUNE 30, 1889.

MADISON, WISCONSIN:
DEMOCRAT PRINTING COMPANY, STATE PRINTERS.
1889.

☞*The Bulletins and Annual Reports of this Station are sent free to all residents of the State who request it.*

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Office and Laboratories, in Agricultural Hall, University grounds.
Experimental farm with buildings join the college grounds on the west.
Telephone connections.

LETTER OF TRANSMITTAL.

MILWAUKEE, Wis., October 1, 1889.

To His Excellency, WILLIAM D. HOARD,
Governor of Wisconsin:

I have the honor to transmit to you herewith, in accordance with law, the Sixth Annual Report of the Agricultural Experiment Station of the University of Wisconsin.

Respectfully,

GEO. H. PAUL,
President of the Board of Regents,
University of Wisconsin.

REPORT OF THE DIRECTOR.

In presenting the Sixth Annual Report of the Agricultural Experiment Station to the farmers of Wisconsin it is with the desire that they may see in its pages evidences of careful work, and the endeavor to make the Experiment Station a source of help to the agricultural interests of the state. Each passing year should mark progress and improvement if we are to keep up with the times; a comparison with earlier reports will give evidence on this point.

The report covers a period from July 1st, 1888, to June 30th, 1889. Of the changes in the Station staff we note that Mr. F. H. King, late of the River Falls Normal School, joined us September 1st, 1888. His coming was for the double purpose of strengthening the teaching force of the Agricultural department of the University, and adding to the Station working force. The work of the Station proper has grown so much, and promised such still further increase, that the Director could not give to the educational side of the department that attention which was essential to its material growth. Mr. King will give half of his time to the wants and advancement of agricultural students and the remainder to agricultural investigations in the direction of soils, drainage, farm buildings and machinery.

Mr. E. S. Goff, of the New York Experiment Station, Geneva, was secured April 1, 1889, to take charge of the horticultural work of this Station, and give instruction in horticulture to agricultural students. The horticulturists of this state have long urged the establishment of a horticultural department as a recognition by the University of their wants in that direction. In Mr. Goff, it is believed, we have a person who will fulfill the desires of our friends in this direction, and we believe that the Station has placed itself in condition to do much for the advancement of Wisconsin's horticulture. Our horticultural appliances are yet very limited, but we propose not long to be in arrears in this line.

It is with regret that the resignation of Mr. F. G. Short, assistant chemist, is noted. Mr. Short has been with us nearly five years, and had already contributed some most valuable results to our knowledge of dairy matters. His investigations of the corn plant, taken up a year since, gave promise of results of much value and importance, evidences of which appear in this report. The training he had gone through at this Station in past years made his services doubly valuable at this time, and his loss is keenly felt. It is pleasant, however, to know that in assuming the duties as chemist to the State Food and Dairy Commissioner, he has only changed from one laboratory to another, and that he is still working for the betterment of Wisconsin agriculture. The Station takes no small pride in the fact that it has prepared a man for this important and honorable position.

During the past year the Station has issued the following Bulletins: No. 16, "A new method for determining fat in milk," July, 1888; No. 17, "Report on corn, oats, barley and potatoes; grape growing," November, 1888; No. 18, "The constitution of milk, and some of the conditions which affect the separation of cream," January, 1889; No. 19, "Notes on ensilage," April, 1889. As required by law we shall continue to issue at least one bulletin quarterly, giving the result of some special line of effort.

We now have over 7,000 names on our mailing list, but the provisions of our state for printing bulletins and reports are so generous that we are yet able to offer all publications from this Station free to any resident of the state who may apply for them.

The continued good will and the earnest support of the President of the University and the whole board of regents, is a source of deep gratification to the Station workers; add to this the expression of good will so frequent from the farmers of the state, and the status of the Station seems eminently satisfactory. With no dissensions within, or harsh criticisms from without, our whole energies can be directed toward research and pushing forward the work of investigation.

An examination of the present work shows that the largest part of the Station's energies is given over to animal husbandry. For this we believe no apology is necessary. Though some lines of this great and highest branch of agriculture are in a somewhat depressed condition at this time, nevertheless live stock must continue to form the basis of agricultural progress in Wisconsin. Because of our full belief in this matter we hold to this line; at the same time we realize that it is the most intricate and perplexing kind of experimental work, and that to continue in it means labor of the most exacting nature. We are dealing with animate objects of complex nature and influenced in a hundred ways by food, inheritance and environment. The more we have to do with livestock the more impressed we become with the complexity of the problems bearing thereon, many of which at first seem very simple and easily solved. We believe, however, that the farmers will bear with us in patience, overlooking the seeming slow returns so long as there is evidence that the best has been done that could be under the conditions at hand. In order to succeed we know and realize that we must concentrate our energies on certain lines of effort, and finish these before starting new ones. If the reader does not find in this Report that which interests him in his own particular line he should remember that the field is a very broad one, and that a single station can cover but a small portion of it.

Our investigations in pig feeding have occupied a considerable part of our time, and are given prominence in this Report because we believe that pork making will continue profitable in the future as it has in the past when intelligently and carefully managed. Dairying has received much attention at our hands because Wisconsin, in its nutritious grasses, its adaptability to Indian corn and clover, with its pure, cool waters, is naturally a dairy state. The agricultural center of the country has moved to the west of us, and our environment is such that we cannot ship out hay and grain to any profit; these must be fed on the farm. Every farmer becomes then, under these conditions, a manufacturer of agricultural products in the shape of pork, beef, butter, mutton, wool, etc., which call for more skill and higher intellect than grain growing. We have taken up sheep feeding, and will make a study of the wool and mutton interest, believing that there is an important place for sheep in our agriculture. In the next report we hope to give facts of interest in this direction.

Most of our farmers appreciate the purpose and use of the Station farm, but there are a few who do not understand its relations to the Station. To make it a model farm, where the visitor can behold the finest buildings, the most elaborate equipment of machinery and grand herds of each of the many breeds of live stock is an experiment of a certain kind in itself. If we were to undertake to carry on such a farm, however, a very considerable sum of money would be required to keep it up to any high standard; each breed of live stock would demand a herdsman or manager, with assistants equal in number and ability to those found on any large stock farm in our state; in the aggregate, a small army of men would be needed to carry out this plan. Even then one would probably be able to see herds of the same breed on stock farms in our state equal or superior to any we might possess. Our progressive breeders, found in every county, who devote their lives to one kind of stock, would be able to show herds equal if not superior to our own. In a small way we should set ourselves up against the breeders of special lines. By dropping the question of breeds altogether and using good, representative animals for feeding experiments, we occupy a field where we come in competition with no one, and where our work may prove of great benefit to the owners of all breeds of stock. With the means at hand it seems far wiser to work at solving the problems of feeding and handling, and leave the battle of breeds to those who enter the warfare so willingly. Visitors to the farm therefore will not find large herds or flocks, but a small number of animals used for feeding trials. We make no effort to carry on a model farm. It is a work place rather, where the equipment is all shaped to the one purpose of carrying on feeding trials. We are pleased to note that many farmers visit the Station during the year, and urge that the number increase.

The agricultural department, comprising the educational work of the Station, now has for its quarters the whole of South Building, a four-story stone structure, which has been partially remodeled and will be further refitted to meet our wants. Visitors to the farm should not fail to call at the Agricultural Hall, where many objects of interest may be found in the laboratories and lecture rooms.

EXPERIMENTS IN PIG FEEDING.

W. A. HENRY.

THE EFFECTS OF DRIED BLOOD, PEA MEAL AND CORN MEAL ON THE CARCASS, BONES AND VISCERA OF THE HOG.

The Fourth and Fifth Reports of this Station, present results in feeding rations rich in carbhydrates, but poor in protein, to certain pigs, and to others, rations rich in protein, and noting the effects upon the carcasses of the animals. In continuation of this work, an experiment is here reported in which we have carried our work further than in the past, and find results entirely concordant with those heretofore obtained.

Two litters, of six pigs each, were selected for this trial. They were Poland-China, having a cross of Jersey Red, a couple of generations back. The first litter was 131, the other 133 days old at the commencement of the trial, at which time the pigs weighed about 100 pounds each. Each litter was divided into three lots of two each. All were liberally supplied with fresh hard wood ashes and salt, and given hard well water in abundance for drink. The first two pigs in each litter were fed a ration made up of one-third dried blood, and two-thirds corn meal; the second two received half pea meal and half corn meal, while the third two in each litter were fed corn meal only. Thus it will be seen that we conducted our experiment in duplicate. The feeding began February 27, 1888, closing July 20 for the first litter, July 26 for the second. This makes a trial of 143 days for the first litter, marked A, and 149 days for the second litter, marked B, in the table. Samples of the food given were analyzed with the results shown below:

Table Showing Composition of Corn Meal, Pea Meal and Dried Blood.

	Corn meal.	Pea meal.	Dried blood.
	Per cent.	*Per cent.*	*Per cent.*
Moisture	12.92	7.07	8.90
Ash	1.20	3.13	3.05
Ether extract	3.76	0.09	0.03
Crude fiber	2.67	3.81	....
Protein	9.24	24.35	82.02
Nitrogen-free extract	70.21	60.96	6.05

The following table presents some of the results obtained:

Table Showing Results of Feeding Trial with Hogs.

	Pigs.	Weight at beginning of trial.	Gain during trial.	Food eaten.	Food for 100 lbs. gain.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
One-third dried blood, two-thirds corn meal	*Lot A.* 1 and 2	179	395	1,611	407
	Lot B. 7 and 8	202	415	1,705	410
One-half pea meal, one-half corn meal	*Lot A.* 3 and 4	199	338	1,562	462
	Lot B. 9 and 10	190	381	1,660	435
Corn meal only	*Lot A.* 5 and 6	191	305	1,459	478
	Lot B. 11and 12	204	316	1,527	483

From the figures in the last column of the table we can calculate the cost of 100 pounds of gain. Taking the average cf the two lots and rating corn meal at $14, peas at $25, and dried blood at $30 per ton, we have:

Cost of 100 pounds of Gain with Pigs.

136 lbs. of dried blood, at $1.50 per cwt	$2 04
273 lbs. of corn meal, at $0.70 per cwt	1 91
	$3 95
225 lbs. of pea meal, at $1.25 per cwt	$2 80
224 lbs. of corn meal, at $0.70 per cwt	1 56
	$4 36
480 lbs. corn meal, at $0.70 per cwt	$3 36

This shows that a greater weight of corn meal was required for producing 100 pounds of gain than of the other two mixtures; but at the prices named, the mixture of peas and corn meal costs the most for the gain produced, the dried blood and corn meal coming second, while the corn meal ration was the cheapest.

It seems marvelous that the corn meal-fed hogs should have lived and thrived during a period of five months beginning in February, enclosed in a pen and small lot, upon a diet of corn meal with only wood ashes, salt and water aditional. Here is further confirmation of the wonderful feeding power of Indian corn.

At butchering, the viscera and blood of each animal were weighed separately. The full report for each animal will be found in the appendix; the general reader is not interested in details, hence only averages will be here presented.

The blood was analyzed to determine the amount of water it contained. The table below presents the results of a study of the blood and livers of each group of four hogs:

Table giving Data Relative to Blood and Livers.

Lots A and B, four hogs on each feed.	Average dressed weight.	Average weight of blood.	Average per cent. of dry matter in blood.	Average total dry matter in blood.	Grams of dry matter in blood to each pound dressed weight.	Average weight of liver.	Grams of liver to 1 pound dressed weight.
	Lbs.	*Grams.*	*Pr. cent.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blood-fed....	247.6	3,305	24.24	801.1	3.23	1,558	6.29
Peas-fed	228	2,879	24.58	707.6	3.10	1,374	6.02
Corn-fed.....	211.5	2,623	24.09	631.8	2.98	1,068	5.04

A study of the table shows:

(1) The total weight of blood from the blood-fed hogs is the greatest, that from the corn-fed hogs being the lowest.

(2) The percentage of dry matter in the blood of the three lots is lowest in the corn-fed hogs, though the difference is not very marked.

(3) Comparing the amount of dry matter in the blood to the dressed weight of the carcasses we find an excess of 7 per cent. for the blood-fed, and 3 per cent. for the peas-fed over those getting corn.

(4) Comparing the weight of the livers to the dressed weight of the carcass we find a difference against the corn-fed hog of over 19 per cent. for the blood-fed, and 16 per cent. for the peas-fed hogs.

Table Giving Weight of Kidneys.

	Blood-fed.	Peas-fed.	Corn-fed.
	Grams.	*Grams.*	*Grams.*
Lot A...............................	301	216.5	162.5
Lot B...............................	246.2	220	171
Average...........................	273.6	218.2	166.7
Grams of kidney to one lb. dressed weight...........................	1.105	0.957	0.788

In the above we note that the kidneys follow the blood and liver in being heavier with the first two lots of hogs than with the last lot. Comparing the weight of the kidneys to the dressed carcass we find a difference of 31 per cent. in favor of the blood-fed and 17 per cent. in favor of the peas-fed over the corn-fed hogs.

The amount of dry matter and fat were determined in the kidneys of Lot B, and the results are presented in the following table:

Table Showing Results of Partial Analysis of Kidneys.

LOT B, ONLY.	Average weight of dressed carcass.	Average weight of kidneys.	Per cent. dry matter in kidneys.	Total dry matter in kidneys.	Per cent. fat in kidneys.	Dry matter in kidneys less fat.	Dry matter in kidneys to one lb. dressed weight.	Dry matter in kidneys less fat to one lb. dressed weight.
	Lbs.	*Gr'ms*	*Per ct*	*Gr'ms*	*Per ct*	*Gr'ms*	*Gr'ms*	*Gr'ms*
Blood-fed..........	256.7	246.2	24.41	60.09	4.71	48.50	0.234	0.188
Peas-fed............	232.5	220.0	25.80	56.76	4.49	46.88	0.244	0.201
Corn-fed............	216.5	171.0	26.26	44.90	6.41	33.95	0.207	0.156

Studying this table we observe:

(1) The same falling off in total weight of kidneys from dried blood-fed to corn-fed animals, as occurred with the blood and liver.

(2) That the lowest percentage of dry matter was found in the kidneys of the blood-fed hogs, and the highest with the corn-fed.

(3) That there was nearly two per cent. more fat in the kidneys of the corn-fed hogs than in the kidneys of the other two lots. This shows that the fattening process reached even the kidneys.

(4) Figuring with or without the fat there was considerably more dry matter in the kidneys of the first two lots than the last lot.

(5) Omitting the fat and figuring upon the proportion of kidneys to dressed weight there was 17 per cent. more dry matter in the kidneys of the blood-fed hogs, and 24 per cent. more dry matter in the kidneys of the peas-fed hogs than in the kidneys of the corn-fed hogs.

MODIFICATIONS OF THE CARCASS.

Does the effect of feed reach still further and modify the carcass of the hog as well as the internal organs? The feeder and breeder may feel inclined to leave the question of the effect of feed upon the viscera to specialists, thinking it beyond their province and of no direct importance; this is hardly correct, for upon the proper size and successful operation of the machinery of the body depends the ultimate success in growing the carcass. It is well to go further and observe whether or not different foods actually modify the animal carcass. Was there a real difference in the proportion of lean to fat meat in the bodies of these hogs?

The last two reports of this Station contain carefully prepared illustrations showing to the eye at a glance that we have found that different foods do affect the size and appearance of the muscles or red-meat of the carcass of hogs. Doubts having been expressed as to the magnitude of the difference and its importance we have gone further in our examination of the present lot of hogs than before. Owing to the weather being extremely warm at slaughtering time we found it impossible to carry out the original plan of making analysis of the whole carcass of the hogs and were obliged to confine ourselves to a small portion of the carcass which, however, we consider fairly representative of the whole. To this end the sixth rib of one side of each carcass, together with that portion of the flesh lying directly over it, was cut out. The rib and the skin were removed and the remaining meat of the section analyzed. In order to study the composition of the red meat by itself the large tenderloin muscle lying along the back, in the angle made by the spinous processes and the ribs, was selected, and that portion lying over the seventh and eighth ribs used. At this point the muscle, which is nearly round, is quite free from attachment so that it is easily and accurately dissected. In all our work parallel determinations were made, so that with four hogs on each lot we have eight analyses of the sixth rib cuts from each of the lots, and as many more of the tenderloin muscle. The average of the analyses are presented in the following table:

Table Giving Analyses of Sections of the Carcass of Hogs.

	SIXTH RIB CUT.			TENDERLOIN MUSCLE.		
Four hogs in each lot.	Water.	Fat.	Dry lean me t.	Water.	Fat.	Dry lean meat.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Blood-fed............	27.16	64.68	8.16	67.96	8.22	23.32
Peas-fed.............	28.41	62.94	8.65	69.49	6.17	24.34
Corn-fed............	20.16	73.56	6.28	67.45	9.41	23.14

With the sixth rib cut we notice a difference in the proportion of water, fat and lean meat, which is very interesting and exceedingly important in its teaching, if interpreted correctly. To more easily understand the figures, let us assume the sixth rib cut as representing the available meat in the carcass, and take 100 lbs. as the basis for comparison. We find from the table that 100 lbs. of carcass of the corn-fed hogs contain:

7.67 lbs. less water than 100 lbs. of carcass from blood and peas fed.

9.75 lbs. more fat than 100 lbs. of carcass from blood and peas fed.

2.12 lbs. less dry lean meat than 100 lbs. of carcass from blood and peas fed.

Studying the figures for the tenderloin muscle we note a surprisingly large per cent. of water present in all cases. Of this muscle about two-thirds is water, one-fourth dry lean meat and the remainder fat. The only difference between the muscle of the corn-fed carcass and that of the other two is an increase of 2.22 per cent. of fat in the former, so that even the so-called lean meat of the corn-fed hogs is the fattest.

While the tenderloin muscle, which we may suppose representative of the lean meat, is about two-thirds water, the whole of the sixth rib-cut including the red meat is about one-fourth water. From these facts it is very evident that the water of the carcass lies in the red meat portion of the body rather than in the fatty tissues; in other words the fatty portion of the carcass is nearly free from water, while two-thirds of the weight of the lean meat may be water.

Assuming that the lean meat of the sixth rib-cut has the same proportion of water that the tenderloin muscle has, and that this cut represents the whole carcass, we find:

For blood-fed hogs	25.4 per cent. of the carcass is lean meat.
For peas-fed hogs	28.3 per cent. of the carcass is lean meat.
Average	26.8 per cent of the carcass is lean meat.
For corn-fed hogs	19.2 per cent. of the carcass is lean meat.

This shows a difference of 7.6 pounds of lean meat per 100 pounds carcass in favor of blood and peas-fed hogs; expressing it in another way, the carcass of the blood and peas-fed hogs contained 40 per cent. more lean meat than the carcass of the corn-fed hogs.

EFFECTS OF RAIN-WATER, WELL-WATER AND BONE-MEAL ON THE GROWTH OF CARCASS AND STRENGTH OF BONES OF PIGS.

Our endeavor was to ascertain:

(1) If the lime of hard well-water adds to the strength of bones of pigs living on an exclusive corn diet.

(2) If feeding bone-meal would strengthen the bones of pigs living on an exclusive corn diet.

A litter of pigs ninety-three days old at the beginning of the trial, was selected for this experiment. They were from a high grade Poland China sow, and sired by a pure bred Poland China. The pigs were divided into three lots of two each; they were kept in pens which opened back to yards, each of which enclosed a space, eight feet wide by fifty feet long. Finding that the hogs ate some of the earth in these yards, during the last six weeks of the trial a portion of the yard next to the pens, 8x15 feet, was fenced off and floored, in order to give the pigs out door room and exercise, but keep them from eating earth.

The food and drink of the pigs were as follows:

Lot I, corn-meal, rain-water, salt and ground bone.
Lot II, corn-meal, rain-water and salt.
Lot III, corn-meal, hard well-water and salt.

The ground bone used in the trial was that sold for fertilizing purposes; it appeared of excellent quality, light colored and clean, and ground about as fine as very coarse corn meal.

The well water used in the experiment was found to contain 40.46 grains of solids per gallon; while the rain water, from a plastered cistern, contained 6.44 grains of solids per gallon. A qualitative test showed that the solids were practically all carbonate of lime, in both cases.

The trial began July 13, 1888, and closed December 10, lasting 149 days. Unfortunately, it did not progress as satisfactorily as we wished, one pig in Lot I, and one in Lot III, not making satisfactory gains compared with the other pig in the same lots. Pig No. 1, of Lot I, showed a poor appetite in October, and made a very slow gain after that time until November 24, when it refused to eat. It was killed November 27, but no evidence of any disorder or irregularity could be found. The viscera appeared healthy and natural, as did the flesh of the carcass.

Pig No. 2, of Lot III, although showing no sign of sickness, made a poor gain.

The following table gives the more important results of the trial:

Table Showing Results of Trial with Pigs fed on Corn Meal, with Rain Water, Well-water or Bone Meal.

LOT.	FOOD EATEN		WEIGHT AT BEGINNING.		GAIN.			Food for 100 lbs. of gain.	Average bkg. strength of thigh bone.
	Corn.	Bone.	No. 1.	No. 2.	No. 1.	No. 2.	Total.		
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
I, Rain water and bone meal......	1,096	31	62	67	86	160	246	454	890
II, Rain wat'r only.......	1,106	......	62	66	106	104	210	526	500
III, Well water only.	1,034	......	70	58	107	73	180	574	442

Full data of the results obtained at slaughtering time are given in the appendix. It is unfortunate that the results are so irregular, since they throw doubts on any conclusions that may be drawn. It is interesting to note, however, that supplying well-water seemed to give no advantage over rain water; indeed the results are against well-water in the amount of gain made, the food required for 100 lbs. of gain, and the breaking strength of bones. Feeding ground bone seems to have greatly strengthened the bones of the pigs getting it, for though we have included in Lot I the pig that sickened and was prematurely slaughtered, we still have for that lot thigh bones of far greater strength than the same bones in the pigs of the other lots.

BONE MEAL AND HARD WOOD ASHES, WITH CORN MEAL FOR HOGS.

The experiment just reported not being satisfactory, a second was undertaken on a modified plan. The dam of the pigs was a grade Poland China, the sire a full-blood Poland China. The pigs were 105 days old when the trial began, November 27, 1888. There were three lots, with two pigs in each lot. They were placed in the regular experimental pens, consisting of a feeding and sleeping room, back of which was a yard, 8x15 feet, with a plank floor, so that the animals could be out of doors at pleasure, but not get to the earth. The feed for these pigs was as follows:

Lot I, corn meal, ground bone, salt and rain water.
Lot II, corn meal, hard wood ashes, salt and rain water.
Lot III, corn meal, salt and rain water.

The ground bone was supplied by the attendant dropping a pinch of it into each feed. The hard wood ashes were placed in a box in the open yard protected from the rain by a covering. A fresh supply was provided every two or three days. Salt was supplied by dropping a pinch into each feed. The attendant used his judgment as to the amount given, regulating it by the actions of the hogs when feeding from the trough. He observed that Lot III did not care for as much salt as the other two lots; this explains the small quantity given them. The corn meal was wet with water. Extra water was given for drink at the beginning of the trial, but when cold weather came on, water in which the feed had been mixed was all that was supplied; it was regulated by carefully watching the amount required by each lot.

Much time was given in noting the wants of the hogs in these little details. Fortunately the trial, which lasted 128 days, went through with no accidents, and the results are presented with confidence in their accuracy and the belief that valuable instruction can be drawn from them.

Table Showiny the Results of Feeding Pigs on Corn-Meal, together with Bone Meal and Ashes.

	Food Consumed.					Weight at beginning.		Gain.			Feed for 100 lbs. gain.	Average bkg. strength of thigh bone.	Ash of thigh bones of lot.
	Corn meal.	Bone meal.	Hard wood ashes	Salt.	Rain wat'r dru'k	No. 1.	No. 2.	No. 1.	No. 2.	Total			
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Grms*
Lot I...	830	16	......	9	1,708	64	64	94	66	160	518	817	164
Lot II..	815	.. ..	30	9	1,698	61	66	86	72	158	515	625	138.1
Lot III.	660	......	......	6	648	66	63	67	49	116	568	305	87.6

In the above table the last two columns of figures may need explanation. The thigh bones of the pigs were dissected and their relative strength determined with the testing machine. The two rounded supporting edges were placed four inches apart and the thigh bones, one at a time laid on these, always in the same position. The breaking edge was brought down vertically upon the bone so as to rest upon it over a point mid-way between the lower plates. The breaking power was applied very slowly and the pressure at which the bone snapped determined.

It will be seen that the difference between the strength of bones in the pigs fed on corn meal only and the other two lots is very great. The bones of Lot III bent very much before breaking, appearing flexible like whale bone, while the other two lots were firm and unyielding. The ash of the bones was determined by placing them in a muffle oven after they had been broken, and burning at a high temperature; the residue was a clear white ash, easily pulverized between the thumb and fingers. The weight of ash of the thigh bones of each lot is given in the above table.

As a consequence of feeding a pinch of ground bone or a handful of wood ashes daily to hogs living on a corn meal diet, we note:

One-third more salt consumed.

Nearly three times as much water drunk.

Almost one-fourth more corn meal eaten.

More than 50 lbs. of corn meal saved in making 100 lbs. of gain in live weight.

More than twice the strength of bone.

Almost twice the amount of ash in the bones.

A careful inspection of the carcass of the hogs failed to reveal any greater development of muscle for the hogs getting ground bone and ashes than for those exclusively corn fed; in other words, the ashes and ground bone strengthened the bones, but did not build up the red meat of the body.

CONCLUSIONS DRAWN FROM OUR EXPERIMENTS ON THE EFFECTS OF VARIOUS FOOD RATIONS ON THE CARCASS OF HOGS.

For the past three years we have been experimenting at this Station for the purpose of determining the effects of various foods upon the carcass, bones and viscera of hogs. In all cases, corn meal has served as a ration for one lot of pigs under study, because corn is and must continue to be the staple hog food at the west. Against corn meal has been fed a ration containing part corn meal, but in addition such other ingredients as dried blood, peas, shorts or skimmilk, foods rich in protein.

The object was to observe the effects of an exclusive or an excessive corn ration, in comparison with a rational one, on the carcass, bones and viscera of hogs; what changes could be produced and how marked. With the results of trials, running through three years, before us there appears to be a good many points which seem significant.

To avoid redundancy the phrase "corn ration" will be understood to mean corn, salt, ashes, and water; "mixed ration" will mean part corn, together with some other article containing considerable protein, as shorts, peas, skim milk, or dried blood, together with ashes, salt and water.

The following points seem to be fair deductions from our investigations:

(*1*) *For the market price, or cost of production, Indian corn is beyond all comparison the cheapest single food article for hogs.*

(*2*) *Hogs will live a long time and make a fair gain upon an exclusive corn ration.*

(*3*) *When kept upon such a ration they grow quite fat, but when yet small, have the form and appearance of mature hogs, being dwarfed in size.*

(*4*) *When kept upon corn ration, with or without ashes, if kept in the pen, hogs seem satisfied; after eating their feed they lie down in apparent comfort to await the next meal.*

(*5*) *The carcass of the hog on corn ration contains more* *fat and less water than does the carcass of the hog on mixed ration.*

(6) The carcass of the hog on corn ration may contain a quarter less muscle or lean meat than that on mixed ration.

(7) Hogs on corn ration have less blood in their bodies than those on mixed ration.

(8) The livers of hogs on corn ration are smaller than those of hogs on mixed ration.

(9) The kidneys of hogs on corn ration are smaller than those of hogs on mixed ration.

(10) The skeleton of the hog on corn ration is lighter than that of the hog on mixed ration.

(11) The hide of the hog on corn ration weighs less than that of the hog on mixed ration.

(12) The hair of the hog on corn ration may be less than that of the hog on mixed ration.

(13) The bones of the hog on corn ration have much less strength than those of the hog on mixed ration.

(14) Hogs living on corn meal, water and salt did not seem to have their bones strengthened by feeding well water, instead of rain water.

(15) Hogs living on corn meal, salt and rain water, had their bones doubled in strength by feeding hard wood ashes, and still further strengthened by feeding ground bone.

(16) Hogs fed on ground bone or hard wood ashes had the ash material of their bones about double in amount, ground bone giving better results than wood ashes.

(17) Hogs living on corn meal, salt and water, when fed ground bone or ashes, drank more water, consumed more food and made much heavier gains than those not getting ground bone or ashes.

(18) There was no increase of muscle with the hogs on the corn ration, getting ground bone or hard wood ashes, over those on the same food, getting no ground bone or ashes.

(19) While the body of the hog, perfect or imperfect, is the result of inheritance, it can be greatly modified by the kind of food given.

WHOLE OATS VERSUS GROUND OATS FOR HOGS.

Next to Indian corn, the oat crop leads in importance for stock feeding at the west, and since the grain of oats contains a larger proportion of protein and ash than does corn, it was considered advisable to undertake feeding trials, to ascertain the proper quantity of oats to be fed with corn, and whether they should be fed ground or unground. The pigs used in their trials were those described on page 25 of this Report. They were from 108 to 125 days old at the beginning of the first trial, December 13, 1888. There were three pigs in each lot. The food given the different lots was as follows:

Lot I, one-third whole oats, two-thirds corn meal.

Lot II, two-thirds whole oats, one-third corn meal.

Lot III, one third ground oats, two-thirds corn meal.

Lot IV, two-thirds ground oats, one-third corn meal.

After continuing each lot on the given feed for thirty days, the rations of Lots II and III were reversed, as were those of Lots I and IV, and a new trial began, after the usual week's preparatory feeding. The trials were continued in this way through four periods, of thirty days each, with the results given in the following table:

Experiments with Ground and Whole Oats for Hogs.

A.— *Whole Oats.*

Feed.	Lot.	Trial began.	Feed eaten.	Weight at beginning.	Gain.
			Lbs.	*Lbs.*	*Lbs.*
Two-thirds whole oats, one-third corn meal............	II	Dec. 13.	282	218	54
	III	Jan. 19.	312	315	66
	II	Feb. 25.	384	373	69
	III	April 3.	410	497	57
One-third whole oats, two-thirds corn meal............	I	Dec. 13.	296	228	71
	IV	Jan. 19.	327	291	76
	I	Feb. 25.	390	376	74
	IV	April 3.	444	470	75

B.— *Ground Oats.*

Two-thirds ground oats, one-third corn meal	IV	Dec. 13.	329	215	75
	I	Jan. 19.	344	301	83
	IV	Feb. 25.	410	368	95
	I	April 3.	510	468	118
One-third ground oats, two-thirds corn meal............	III	Dec. 13.	377	227	94
	II	Jan. 19.	398	281	102
	III	Feb. 25.	458	390	109
	II	April 3.	606	465	152

From this table we deduce the following:

Food Required for 100 lbs. of Gain.

Feed.	Lot.	Oats whole.	Lot.	Oats ground.
		Lbs.		*Lbs.*
Two-thirds oats, one-third corn meal.	II	522	IV	439
	III	473	I	414
	II	557	IV	432
	III	719	I	432
One-third oats, two-thirds corn meal.	I	417	III	401
	IV	430	II	390
	I	527	III	420
	IV	592	II	399

Averages.

Two-thirds oats, one-third corn meal.	II & III (2 trials each.)	568	I & IV (2 trials each.)	429
One-third oats, two-thirds corn meal.	I & IV (2 trials each.)	492	II & III (2 trials each.)	403

Our success with this experiment was remarkable, since four lots of hogs, of three each, were carried through four separate feeding trials, or sixteen in all, of thirty days each, without a single animal getting off feed, or showing indisposition in any way whatever. All of the conditions of the trials are such as to make the figures very valuable in what they may teach. Tracing the figures down to the table of averages we note:

That the poorest result was obtained from the ration composed of two-thirds whole oats and one-third corn meal.

The next poorest result was obtained where one-third whole oats were fed with two-thirds of corn meal. By cutting down the oats of the ration from two-thirds to one-third, substituting corn meal for the oats, there was a saving of 76 lbs. on 568 lbs.

Where two-thirds of the ration consisted of ground oats with one-third corn meal, the very excellent results of 100 lbs. gain from 429 lbs. of feed is secured, as the average of four trials.

Where the ration contained one-third ground oats and two-thirds corn meal, the average of four trials shows that only 403 lbs. of feed were required for 100 lbs of gain. This is the best average ever attained by us in any feeding trial with hogs as old as these, and shows in a remarkable degree the value of the oats when mixed with corn. When we further reflect that by feeding oats to hogs we have given them a feed adapted to building up bone and muscle, we then appreciate the value of the lesson of these trials. It will be seen that for such hogs, when fed for rapid, heavy gains, the oats should always be ground, and the quantity limited in the ration to something like one-third of the total amount. It is high time that our farmers come to learn that oats are just as valuable for building bone and muscle in a pig as in a colt.

For older hogs, especially brood sows, when maintenance and not rapid gain is desired, the experience of some of our most careful stockmen shows that oats can be fed unground with the best of results. They should then be scattered thinly over the feeding floor so as to induce slow eating and thorough mastication.

SKIM MILK FOR MATURE VERSUS GROWING HOGS.

Four grade Poland China hogs, two in each lot, were used in this trial. The hogs in Lot I were 255 days old at the beginning of the trial, and the hogs in Lot II were 126 days old. The trial commenced December 18, 1888, and continued for sixty-three days. The hogs were given all the skimmilk they could drink, with a little corn meal stirred into it, in addition.

Results of Trial.

	Weight at beginning.	FEED CONSUMED.		Gain.
		Skim milk.	Corn meal.	
Lot I, mature hogs	400 lbs.	2764 lbs.	531 lbs.	193 lbs.
Lot II, growing hogs.....	144 lbs.	1680 lbs.	286 lbs.	164 lbs.

Food Required for 100 *lbs. of Gain.*

	Skim milk.	Corn meal.
Lot I..	1430 lbs.	301 lbs.
Lot II..	1024 lbs.	174 lbs.

EXPERIMENTS WITH PIGS BEFORE AND AFTER WEANING.

The study of hog feeding must begin with the pig at birth, to be thorough and complete. To enlarge our knowledge of pig feeding four farrowing sows were selected for experiment; the pigs from these were weighed as soon as born and weekly thereafter until weaned. From the date the sows were first weighed, which was a couple of weeks after farrowing, an account was kept of all food consumed, so that we have the data for a study of the food required to maintain pigs through the dam's milk. With three lots, the pigs were induced to consume as much food as possible, in addition to the milk supply of the mother; the fourth lot was fed up to weaning entirely upon the dam's milk. The meal fed to the sows and pigs consisted, in all cases, of half corn meal and half shorts (middlings or shipstuff). The skimmilk was well skimmed and sweet at the time it was fed. The earliest date given in the table is that upon which the pigs were born, and shows the weight of each upon that day. The sows were all young, being about eleven months old at the time the pigs were born, these being their first litters. The sows of Lots I and II were Poland Chinas, with a Jersey Red cross, several generations back; those of Lots III and IV were high grade Poland Chinas, the breeding of which we cannot give, as they were purchased for the experiment. The sire of all the pigs was a full blood Poland China.

The pigs were weaned when 70 days old, and the feeding kept up for a few weeks longer, to observe the value of feed upon the same pigs when weaned. After going off the second experiment they were continued on the oats experiment, also described in this Report. The tables give the other facts essential to an understanding of the experiment:

Experiments with Pigs, Before and After Weaning — Lot I.

Before Weaning.

DATE.	Days from birth.	W'g't of sow.	WEIGHT OF PIGS.								Feed Consumed.
			No. 1.		No. 2.		No. 3.		No. 4.		
		Lbs.	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	
Aug. 10.	0	......	3	4	2	14	3	7	2	10	*By the sow,* 328 lbs. of corn meal and shorts equal parts, together with 638 lbs. of sweet skimmilk.
Aug. 11.	1	......	3	8	3	1	3	10	2	12	
Aug. 12.	2	......	3	14	3	5	3	15	3	..	
Aug. 13.	3	.....	4	4	3	10	4	5	3	5	
Aug. 20.	10	......	7	10	6	4	7	10	5	10	
Aug. 25.	15	235	9	11	8	2	9	14	8	2	
Sept. 1.	22	246	13	5	11	..	13	10	11	6	
Sept. 8.	29	244	16	7	14	6	17	4	14	6	*By the pigs,* 59 lbs. of corn meal and shorts equal parts, together with 263 lbs. of sweet skimmilk.
Sept. 15.	36	235	19	3	17	6	20	10	17	12	
Sept. 22	43	238	22	10	19	10	24	14	21	4	
Sept. 29.	50	246	27	2	23	13	32	5	25	..	
Oct. 6.	57	252	32	..	29	2	37	4	28	12	
Oct. 13.	64	253	37	12	34	7	43	6	34	10	
Oct. 16.	67	257	40	12	36	12	47	7	37	10	
Oct. 19.	70	264	42	..	38	2	48	10	39	..	
Gain .	......	29	32	5	30	..	38	12	30	14	

After Weaning, 46 *Days.*

Oct. 19................	42	..	38	2	48	10	39	..	392 lbs of corn meal and shorts equal parts, 916 lbs. of sweet skimmilk.
Dec. 4.................	83	8	79	8	89	..	72	..	
Gain.............	41	8	41	6	40	6	33	..	

Lot II. — Before Weaning

DATE.	Days from birth.	Wg't of sow.	WEIGHT OF PIGS.								FEED CONSUMED.
			No. 1.		No. 2.		No. 3.		No. 4.		
		Lbs.	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	
Aug. 14.	0		2	5	2	9	2	12	2	8	*By the sow*, 356 lbs. of corn meal and shorts equal parts, together with 654 lbs. of sweet skimmilk.
Aug. 20.	6		4		3	4	3	11	3	2	
Aug. 25.	11	252	5	8	3	10	4	9	5	4	
Sept. 1.	18	259	8	7	4	10	6	13	8	9	
Sept. 8.	26	260	11	12	7		10	4	12	4	
Sept. 15.	33	256	14	1	9	6	13	10	16		
Sept. 22.	40	263	16	2	11	2	15	2	18	13	
Sept. 29.	47	268	17	7	12	7	14	8	19	12	
Oct. 6.	54	273	20		14	11	19		21	12	*By the pigs*, 45 lbs. of corn meal and shorts equal parts, together with 249 lbs. of sweet skimmilk.
Oct. 13.	61	275	25	6	20	8	25	4	26	10	
Oct. 16.	64	279	27	9	22	12	27	6	28	12	
Oct. 23.	70	285	31	8	27	12	32	2	34		
Gain..	.....	33	26		24	2	27	9	28	12	

After Weaning, 42 *Days.*

Oct. 23...............	31	8	27	12	32	2	34		311 lbs. of corn meal and shorts equal parts, together with 832 lbs. of sweet skimmilk.
Dec. 4...............	69		53	8	70		76	8	
Gain...............	38	8	25	12	37	14	42	8	

Lot III.— Before Weaning.

DATE.	Days from birth.	Weight of sow.	WEIGHT OF PIGS.																		FEED CONSUMED.
			No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		No. 7.		No. 8.		No. 9.		
		lbs.	*lbs.*	*oz*	*lbs*	*oz*	*lbs.*	*oz*	*lbs.*	*oz*	*lbs.*	*oz*	*lbs.*	*oz*	*lbs.*	*oz*	*lbs.*	*oz*	*lbs.*	*oz*	
Aug. 14	0	......	2		1	12	1	12	2	1	1	15	1	13	1	15	1	10	1	10	*By the sow*, 343 lbs. of corn meal and shorts, equal parts, together with 1.044 lbs. of sweet skimmilk.
Aug. 20	6	......	4	2	3	10	3	4	4		3	8	3	14	4	4	3	12	3	11	
Aug. 25	11	214	6	9	5	11	5		6	5	5	2	5	14	6	7	5	9	5	9	
Sept. 1	18	212	9	9	8	11	6	8	8	4	7	11	9	4	9	7	8	1	7	12	
Sept. 8	25	208	10	14	10	8	9	6	11	10	9		12		11	10	10	14	9	6	
Sept. 15	32	202	12	10	10	14	11	8	14		11	4	14	4	13	9	13	8	11	3	
Sept. 22	39	209	14	8	12	14	14	8	16	6	14	12	16	12	15	12	14	3	15		*By the pigs*, 140 lbs. of corn meal and shorts, equal parts, together with 547 lbs. of sweet skimmilk.
Sept. 29	46	212	16		14	7	17	4	17	5	16	8	16	12	20		13		16	4	
Oct. 6	53	206	19		15	12	22		22	12	21		20	12	24	12	17	12	20		
Oct. 13	60	204	25	11	17	4	28	2	28	8	27		25		33	8	24		26	6	
Oct. 16	63	209	28		18		30	7	30		29	7	27	12	34	8	26	12	29	13	
Oct. 23	70	208	33		20	12	36	7	34	12	35		31	12	41	6	34	8	34	4	
Gain...		—6	26	7	15	1	31	7	28	7	29	14	25	14	34	15	28	15	28	11	

After Weaning — 28 days.

Oct. 23..............	33	......	36	7	34	12	35		31	12	41	6	34	8	34	4	416 lbs. of corn meal and shorts, equal parts, together with 877 lbs. of swee skimmilk.
Nov. 20..............	54	......	62	8	59	8	60	8	54		63	8	62	8	59	8	
Gain..............	21	......	26	1	24	12	25	8	22	4	22	2	28	0	25	4	

Lot IV.—Before Weaning.

DATE.	Days from birth.	Weight of sow.	WEIGHT OF PIGS.												FEED CONSUMED.
			No. 1.		No. 2.		No. 3.		No. 4.		No. 5.		No. 6.		
		Lbs.	*Lbs.*	*oz.*	*Lbs.*	*oz.*	*Lbs.*	*oz.*	*Lbs.*	*oz.*	*Lbs.*	*oz.*	*Lbs.*	*oz.*	
Aug. 26	0	....	2	4	2	11	2	10	2	5	2	6	1	13	*By the sow*, 385 lbs. of corn meal and shorts, equal parts, together with 845 lbs. of sweet skimmilk.
Sept. 1	6	235	4	1	4	6	5	5	4	6	5	6	3	10	
Sept. 8	13	230	7	7	8	10	8	14	7	10	7	4	6	15	
Sept. 15	20	225	11	..	11	14	12	9	10	..	9	9	10	10	
Sept. 22	27	232	14	2	16	..	15	8	12	14	11	6	12	1	
Sept. 29	34	235	15	..	16	8	18	10	14	12	11	..	16	2	*The pigs received no additional feed.*
Oct. 6	41	232	11	8	17	..	19	2	16	..	12	4	16	2	
Oct. 13	48	236	....		21	10	22	14	19	7	15	8	19	10	
Oct. 20	55	236	....		27	6	28	7	23	2	19	13	23	6	
Oct. 27	62	240	....		29	.	34	8	27	8	25	..	29	..	
Nov. 4	70	239	....		36	8	42	..	31	..	34	..	36	..	
Gain.	......	4	....		32	2	36	11	26	10	28	10	32	6	

After Weaning.—30 Days.

Nov. 4........	36	8	42	..	31	..	34	..	36	..	278 lbs. of corn meal and shorts, equal parts, together with 835 lbs. of sweet skimmilk.
Dec. 4	64	..	75	..	66	..	62	..	67	..	
Gain...........	27	8	33	..	35	..	28	..	31	..	

From those tables we have the following:

Results of Feeding Trials.

	Lot. I.	Lot. II.	Lot III.	Lot IV.
Before weaning.				
No. of days,	55	59	59	64
No. of pigs with the sow	4	4	9	6
Total gain of sow and pigs	160 lbs.	139 lbs.	243 lbs.	160 lbs.
Food consumed:				
Corn meal and shorts	387 lbs.	401 lbs.	483 lbs.	385 lbs
Skim milk	901 lbs.	903 lbs.	1591 lbs.	845 lbs.
Food for 100 lbs. of gain, corn meal and shorts	241 lbs.	288 lbs.	198 lbs.	240 lbs.
Skim milk	563 lbs.	649 lbs.	654 lbs.	528 lbs.
After weaning.				
No. of days	46	42	28	30
No. of pigs	4	4	8	5
Total gain of pigs	156 lbs.	144 lbs.	195 lbs.	154 lbs.
Food consumed:				
Corn meal and shorts	392 lbs.	311 lbs.	416 lbs.	273 lbs.
Skim milk	916 lbs.	832 lbs.	877 lbs.	835 lbs.
Food for 100 lbs. of gain, corn meal and shorts	251 lbs.	215 lbs.	213 lbs.	177 lbs.
Skim milk	587 lbs.	577 lbs.	449 lbs.	542 lbs.

In order to show the amount of food required for 100 weight of gain, before and after weaning, and its cost, the following table is presented:

Table Showing the Amount and Cost of Food Required for 100 *Pounds of Gain.*

	SOW AND PIGS BEFORE WEANING.				PIGS AFTER WEANING.		
	Meal.	Milk.	Cost.		Meal.	Milk.	Cost.
Lot I.	241 lbs.	263 lbs,	$3 10	Lot I....	251 lbs.	587 lbs.	$3 23
Lot II.	288 lbs.	649 lbs.	3 44	Lot II....	215 lbs.	577 lbs.	2 95
Lot III.	198 lbs.	654 lbs.	3 03	Lot III....	313 lbs.	449 lbs.	2 61
Lot IV.	240 lbs.	528 lbs.	3 00	Lot IV....	177 lbs.	542 lbs.	2 60
Average	242 lbs.	598 lbs.	$3 14	Average ...	214 lbs.	539 lbs.	$2 85

In the table the meal (corn and shorts, half and half) have been rated at $14 per ton, and the sweet skim milk at twenty-five cents per hundred pounds. These are most satisfactory results in both cases, and the difference between the amount of food required before weaning and after (about 10 per cent.) is too insignificant to spend time in discussing, especially when we reflect that the larger amount includes the keep of the dam.

The teaching of these trials is that it pays to feed sows when suckling pigs so heavily that the dams, even, will gain in weight, for the cost of the gain made by the pigs and their dam is then cheaper than the gain of the same pigs when grown. The feeder will often find in his herd, however, sows whose tendency toward milk giving is so much greater than their ability to consume and digest food, that they will waste away quite rapidly while suckling their litter.

LENGTH OF INTESTINES OF HOGS.

In his work on "Animals and Plants Under Domestication," Darwin, speaking of the hog, says:

"The nature of the food supplied during many generations has apparently affected the length of the intestines; for, according to Cuvier, their length to that of the body in the wild boar is 9 to 1,—in the common domestic boar as

13.5 to 1,—and in the Siam breed as 16 to 1. In this latter breed the greater length may be due either to descent from a distinct species or to more ancient domestication."*

From the tables given in the appendix the one here presented is deduced. The length of the body was obtained by drawing a tape line from the root of the tail to the tip of the snout, as the carcass hangs suspended after slaughtering; the length of the large and of the small intestines are given separately and combined; also the ratio of these to the body.

Relation between Length of Body and Length of Intestines in Hogs.

Experiments.	No. of hogs in each trial.	Average length of body.	Average length large intestines.	Average length small intestines.	Total average length of intestines.	TIMES LENGTH OF BODY.		
						Large intestines.	Small intestines.	Total intestines.
		Feet.	*Feet.*	*Feet.*	*Feet.*			
II.........	6	3.88	14.28	54.70	68.98	3.68	14.10	17.78
III..	9	2.82	14.87	55.29	70.16	5.27	19.60	24.97
IV........	12	3.74	15.68	60.33	75.96	4.19	16.13	20.32
V	6	3.18	14.88	56.18	71.06	4.67	17.62	22.29
VI........	6	3.12	13.60	54.05	67.65	4.36	17.32	21.68
Average for 39 hogs..........								21.49

It will be seen that the total length of the intestines of the hogs examined by us ranges from over eighteen times the length of the body to nearly twenty-five times the length of the body. Darwin puts it, as seen above, as 13.5 to 1, so that now we may say that the intestines of the modern improved hog is nearly two and one-half times that of the wild hog, and nearly one and one-half times as long as the common animals from which the data used by Darwin were obtained. This fact is an interesting one, for several reasons, and shows better perhaps than any other figures that could be produced, the wonderful changes that have been going on in recent years. Without doubt, the modern improved hog has undergone the greatest changes at the hand of man of any of our domesticated animals. This result has been brought about because of the great unanimity of breeders in pushing the animal toward early maturity, and the largest gain for a given amount of food consumed. The wonderfully increased length of the intestine may be supposed very properly to show that the power of the digestive apparatus has been greatly increased. It may not be that the modern hog can digest his food any more thoroughly than his ancestors, though I suspect he can, but it is altogether probable that he is enabled to eat larger quantities of food in a given time, and therefore give better returns for what is fed him. Perhaps we have about reached the profitable limit in this direction, and should now turn our attention towards improving the quality of the flesh made.

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* Darwin, Animals and Plants Under Domestication, I, 77.

THE RELATION BETWEEN WEIGHT OF HOGS, GAIN MADE, AND FOOD REQUIRED FOR 100 POUNDS OF GAIN.

The following table of general averages is deduced from the tables in the appendix, giving summary of trials; it presents in a condensed form the results of over 100 feeding trials, with over 300 hogs, ranging in weight from under 50 to over 300 lbs.

No explanation of the method of deriving this table is needed, excepting the figures of the last column, perhaps. To ascertain the food required for 100 lbs. of gain the total food consumed during the trials with hogs of each group was divided by the total gain of the hogs in that group. This method of determining the food required for 100 lbs. of gain for each group is considered correct. It is not considered correct to add the figures for food required for 100 lbs. of gain for each lot in the group and divide this by the number of trials in the group.

Table giving the Relation between Weight of Hogs and Food eaten, Gain made and Food required for 100 *lbs. of gain.*

No. of group.	Group.	No. of hogs in group.	Average weight per hog.	Food eaten per hog per day.	Gain per hog per day.	Food for 100 lbs. of gain.
	Lbs.		*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1	Und'r 50	12	48	2.36	.864	273
2	50–100	48	79	3.38	.908	372
3	100–150	71	127	4.11	.940	437
4	150–200	97	176	5.89	1.023	479
5	200–250	49	212	6.93	1.240	561
6	250–300	23	266	7.18	1.415	507
7	300–350	6	340	6.07	1.433	423

The above table, although not entirely satisfactory, presents some interesting figures. Where milk was used as a feed or partial feed it was made to correspond to the other food articles used, by reducing it to dry matter with 15 per cent. water. It will be seen that the first group of twelve hogs, averaging forty-eight pounds apiece, ate 2.36 pounds of feed per day, gained .864 pounds per day, and required only 273 pounds of food to make 100 pounds of gain. With these animals, however, milk formed an important part of the ration. Its high digestibility gives it a great advantage over the other feeds, even where it has been reduced to eighty-five per cent. solid matter. With a large number of experiments and the same general foods used, as with the other lots, the food required for 100 pounds of gain would probably have been over 300 pounds, as here given. It will be seen that with group No. 2, 372 lbs. were required, showing a very favorable gain for food consumed. There is a considerable increase of feed required for the third group, while the fourth shows but little more than the third. In the fifth group there is a jump of over 100 lbs. of feed for 100 lbs. of gain; without doubt this is much too high. It comes in a measure from including in the group the results of trials with feeding sorghum seed, which did not give satisfactory gains for food consumed, probably 500 lbs. of food for 100 lbs. of gain would be nearer correct. Were this reduction made, the figures of the sixth group would be satisfactory about as they stand. For the seventh group the results are highly satisfactory for the feed consumed, and show that it is possible to get as good gains with hogs weighing nearly 350 lbs., as with those weighing less than 150 lbs. In these trials the hogs were fed milk with their grain; to this fact and the small number of animals in the group should be ascribed this very remarkable result. Trials where corn is used with hogs of this weight will probably show 600 lbs. of food required for 100 lbs. of gain.

It will be seen that the hogs ate from 2.36 lbs. to 7.18 lbs. per day, the largest ate just three times as much per day as the smallest hogs. The gain per day runs from .864 to 1.433 lbs., so that while the largest hogs ate three times as much they did not gain twice as fast as the smallest ones. The results of extended trials will doubtless show that a hog weighing over 300 lbs. requires twice as much food for 100 lbs. of gain as the pig under 50 lbs., and that there is a gradual increase in the food required for a given gain from the younger, light animal to the heavier one, approaching maturity.

In reviewing these results it should be distincly borne in mind that, in many of the trials, we were not feeding to get the best results from the feed at hand; in most cases two lots of pigs were fed against one another to observe the effects of different foods, or different combinations, or methods of preparation. Usually one of the two ways was superior to the other. In other cases, trials with single kinds of food were continued too long to give the best results with that food. In general, all of the trials have been for the purpose of enlarging our knowledge of hog feeding; consequently, tables like the above should not be looked upon as giving absolute, but only approximate data.

PRACTICAL CONCLUSIONS.

All things considered the hog has been the most profitable animal on western farms, and no small part of the wealth of the western states is due to this one animal. Corn is and has been the almost universal food for swine in this section, and so it is to Indian corn that we are indebted for the benefits accruing from the hog. No other plant furnishes so much available food to the acre or food that is so well relished by the hog as corn. With millions of acres of land devoted to corn growing, and a large part of this corn being fed to hogs, it is no wonder we have come to regard corn as made for the hog and the hog for corn. To one who first acquaints himself with the situation it might appear that all the farmer has to do to increase his income is to plant more corn and raise more hogs, but the investigator will soon find that were the market open to all that could be raised, there seems a limit to the pork production of any farm or locality, for numerous difficulties beset this vocation. Pigs are born only to meet an early death; hog cholera devastates large areas, passing from point to point with great rapidity, clearing everything before it, leaving the farms not only without swine but so inocculated with the disease that all business in that section must be held in abeyance for a year or more. Farmers are constantly complaining that their hogs become too fine boned, and get but temporary relief by sending off to breeders for coarse boned sires. These facts show that as now handled on the average farm at the west, the hog is in an abnormal condition and that degeneration is constantly going on, or popularly stated, "the stock runs out." The difficulties in the way do not end with the troubles named, but follow the hog even after death, into the pork barrel. Foreigners claim that our pork is diseased, and place an embargo upon it. Home consumption is decreasing, not because our people think the pork is diseased in itself necessarily, but because the meat is so excessively fat that there arises a strong aversion against it in the minds of most people. As people in the lower classes in life get ahead in the world they give up pork for more expensive meat. Not only, then have we to consider the questions of hog feeding from the standpoint of the feeder and breeder, but the opinion and wish of the consumer must receive attention if this industry, of such great magnitude, is to continue on a sound basis.

That with proper care the form, size, substance and bone of the hog can be well maintained, and even advanced, is shown by the fact that careful, intelligent breeders and specialists hold their stock up to a high standard of excellence, and even improve it. Nor is it difficult for the intelligent farmer to keep his stock where it will yield a satisfactory profit. First of all there must be a careful discrimination between the hogs used for breeders and those intended only for feeders. Breeding from immature stock must be avoided as much as possible, for this is probably one of the greatest sources of the present lack of constitution. To fatten brood sows after they have farrowed off litters once or twice, is a practice most unfortunately altogether too common. Good mothers should be held for breeders as long as possible. The care of the pig must begin before it is born, by not only giving the dam comfortable quarters, but supplying such food as is essential for the building up of the bodies of her young. During pregnancy the sow should receive plenty of protein food, in the shape of blue grass or clover pasture, bran, shorts, middlings, shipstuff, skimmilk and peas. It is impossible to keep brood sows through the winter on Indian corn alone, and have good results at farrowing time. Even if large litters of pigs are successfully brought into the world by dams so fed, there must be a weakening of constitution which sooner or later will bring disastrous results. Since it is the cheapest food on the list, corn very properly may form part of the ration of hogs at all times, but to cause a brood sow to not only maintain her own life but to grow the bodies of a litter of young from the elements contained in the daily ration of corn is simply out of the question. There are not enough bone and muscle elements in the corn a brood sow can consume to suffice for building up the bodies of her young.

Unless the farmer has the proper buildings and conveniences for attending to the wants of brood sows it is better to have the pigs born in the summer time, when the mothers are running on pasture, for with pigs brought into the world under such conditions the risk is reduced to the minimum. When born it is profitable to push the pigs forward as rapidly as possible by feeding the mother heavily on nutritious diet, which should contain a very considerable amount of protein and ash elements, since the bodies of young pigs expand rapidly and should be built up in bone and muscle and not fat. The cheapest gain made by hogs at this Station was when feeding sows with young pigs, so heavily that they even gained in weight, while suckling their young. Less than three pounds of feed then made a pound of gain. Having grown a strong muscular frame the time comes when the farmer must separate the breeding stock from the remainder of the herd and give it different treatment. Breeding stock should be kept out of doors, on pasture as much as possible, and every attention given towards keeping the animal natural and healthy. The final purpose to which hogs for the market are intended must direct the way in which they are handled. With a well grown carcass of 100 lbs. for a basis, hogs which are intended for the general market can be fed almost exclusively on corn, adding a little ground oats, shorts, skimmilk or other protein food. As far as possible, however, in these times of low prices, hogs should be grown on pastures, and corn used only to ripen up the animal. On our western farms land is the cheapest and labor the dearest thing we have. The hog that runs in a clover field or blue grass pasture waits on himself, and makes a healthy growth, if not a very fast one. This growth is usually more profitable than that made from entire grain feed. Usually a part ration of grain can be profitably fed to grazing hogs to hasten their growth.

Where the general market is the destination, one cannot be over particular about the pork product, but must manage it at all points in the very cheapest way.

Farmers who are fattening steers should try feeding shelled corn, and putting hogs with them. Our experience shows that the farmer who stanchions or ties up steers and gives corn meal for the main feed, produces about the dearest beef that can be made. Let the steers run loose in an open yard or shed, with a good vigorous shote for each steer. The shote may yield some profit to the owner, if the steer does not.

There is a growing demand for clean, wholesome pork which should be catered to by intelligent farmers. Thousands of people are willing to pay increased prices for pork made from healthy, well fed animals, kept in a cleanly manner. There is no reason why farmers cannot co-operate and establish small packing houses which shall send out smoked ham, breakfast bacon, sausage and lard, which will be eagerly bought up at good prices by a discriminating public. The marvelous growth of the creamery business in the west during the last decade, hints at what may be done in the pork trade. If the butter trade of the west was controlled by a few operators in Chicago who received the whole product and distributed it back again to the people, there would be no demand for intelligent dairying. A pound of butter oil produced by one party would sell for as much as that produced by another, and the large manipulators would make all the profits. A market for choice pork must be created and enlarged and the public properly informed of the situation before this matter will take proper shape. The plan is feasible, and certain sooner or later to be brought about.

Hogs fed to produce a large percentage of lean meat must, to be profitable, sell for at least 20 per cent. more than current prices; a discriminating market will soon pay this difference. Every animal requires a certain amount of food for its maintenance; the hog is no exception, and in feeding we should remember that he will attend to his own bodily wants first of all and only lay on flesh afterwards.

With his wonderful appetite and immense digestive powers, it is the height of folly to keep the hog on part rations. It is the satisfied, quiet hog that brings money to the owner. On the other hand, we have found that our best gains came from hogs so anxious at meal time for their feed that they would show their greedy appetite by squealing. We do not believe in the practice of keeping feed before the hogs at all times. In order to make first class pork, cleanliness is the first requisite. Not only should the pigs be kept in clean quarters, but their food should be clean and wholesome. The dairy farmer is well situated for producing this kind of pork, since skim milk and butter milk are rich in both protein and ash. Where the largest gain only is considered, we have not found it advisable to feed over two or three pounds of skim milk to one of corn meal. A larger amount of milk would give a somewhat increased amount of lean meat, but hardly enough to pay for the increased cost which the milk would necessitate. The limit for the amount of milk to meal, just given, should not be exceeded, but additional protein food furnished in the form of oats, shorts or pea meal. Where peas can be grown they are admirable protein food, and should make a choice quality of pork. Peas can be sown broadcast in early spring, and when ripening can be fed down by hogs at no expense for gathering the crop. Our feeding trials show that oats are an admirable accompaniment to corn, the combination giving the best returns we have made, excepting skim milk and corn meal. The protein and ash of the oat reinforces the corn meal, and the combination should give pork of fine quality. It is believed that there is a limit to the amount of lean meat which can be produced in a hog's body. An excessive proportion is certainly not as desirable as it might seem at first thought. Unless there is a due proportion of fat interlarded with the lean, marbled as we commonly say, the meat will be flavorless. The flavor of good meat comes quite largely, no doubt, from the mixture of fat with lean. This should be borne in mind in producing meat of good quality. High grade pork will not permit the hog from which it is made to become too heavy, since most of the increase, after reaching a certain point, is only fat. Two hundred or 250 lbs. is probably the limit for the best class of carcasses of the kind under consideration, with the large breeds common at the west.

In this review of our work we started out with a statement of the prevalence of corn for hog feeding at the west. All through our work we have been surprised at the power of this grain for producing gain. We have also been surprised to see how perfectly satisfied the hog was when existing upon a corn diet. It is plain to any one who studies the subject, even casually, that as the prosperity of the west in the past has been based upon corn, so corn must continue to be the great money making crop of that section. If pork raising is to continue one of the leading industries, a large part of the product must continue to be the result of feeding corn. There is no doubt but what corn makes pork of fine quality and great firmness, if properly fed. It should be distinctly borne in mind then, that we have not a word to say against the use of corn for pork production. It is against the abuse of corn, and not its use, that we have written. Intelligently fed, corn is all right; only in its abuse is there any wrong. There need be no less corn fed, but more protein food should be given in the shape of clover, blue grass, oats and other grains, along with the corn now given them.

We cannot close this article without alluding briefly to the importance of feeding ashes to hogs. Many farmers are obliged to feed corn in large quantities upon prairie farms, where hard wood ashes are scarce or unknown, and yet upon these very farms there is the greatest need of ash material for aiding in building up the bone of hogs. Corn cobs furnish a very strong ash and should be burned and the ashes carefully saved and fed to the hogs.

VARIATIONS IN THE YIELD AND QUALITY OF MILK.

S. M. BABCOCK.

A careful inspection of the daily milk yield from almost any cow will show considerable fluctuation from day to day, which often amounts to more than fifteen per cent. of the average yield. If in addition to the weight of milk we have data showing the per cent. of fat in the milk we find that this varies to even a greater extent than does the quantity of the milk given, so that it is not uncommon for the total weight of fat contained in the milk from the same cow on two consecutive days to vary more than 50 per cent. of the average daily yield. There is, of course, sometimes a gain and sometimes a loss, so that when several days are grouped together the gains and losses nearly balance each other, and the variations mostly disappear. The causes which lead to these variations cannot always be traced. They occur when no changes have been made in the food, and when the conditions under which the cow is kept have been maintained as uniform as possible. Four cows, taken at random from the Station herd, gave the following average daily variations in the yield of milk for the month of April.

Daily Variations in Milk Yield.

	Average yield.	Average daily variation.	Greatest variation.
No. 1	21.5 lbs.	1.8 lbs.	3. lbs.
No. 2	25.6 lbs.	1.32 lbs.	3.6 lbs.
No. 3	17.7 lbs.	1.50 lbs.	3.8 lbs.
No. 4	23.9 lbs.	1.18 lbs.	3.4 lbs.

These variations are not unusual, as the inspection of yields of milk in official tests will show, and I think it safe to conclude that the average daily variations for the entire season in the yield of milk from any single cow will not be less than 5 per cent. of the average yield. As has already been stated, the variations in quality are usually greater than those in the yield. The following table shows the average daily variations of the fat from the milk of a number of cows in the Station herd for one week in the month of April:

Daily Variations in Fat Produced.

	Average yield fat.	Average daily variation.	Greatest variation.
No. 1	.759 lbs.	.058 lbs.	.145 lbs.
No. 2	.698 lbs.	.068 lbs.	.103 lbs.
No. 3	.794 lbs.	.072 lbs.	.142 lbs.
No. 4	.541 lbs.	.035 lbs.	.065 lbs.
No. 5	.975 lbs.	.065 lbs.	.132 lbs.

This shows an average daily variation of about 8 per cent. in the yield of fat, and is no greater than is shown by the variations of butter in most official tests.

Our experimental work during the past year has directed attention especially to these variations, and has served to indicate some causes for them which have not been given much prominence by writers upon dairy matters. It is generally considered, when the farmer has supplied a sufficient amount of proper food, and has provided good shelter and care for his cows, that he has done all that it is possible for bim to do in order to secure an abundant yield of rich milk, and the cow is usually held responsible for any failure. All of these conditions are of course essential for the best results, but the immediate conditions under which the milking is done appear to have almost as much influence upon the yield and quality of milk as any other factor. The manner of milking, the frequency with which it is done, and the time occupied in doing it may, I believe, have more influence with many cows upon the yield and quality of milk than the kind of food, so long as sufficient nutriment is supplied. All of our experimental work indicates that temporary conditions existing only at the time of milking, may very materially effect both the yield and quality of milk produced. This can be most easily explained by assuming that the milk glands are most active at this time and that the quality of the secretion depends upon this activity. It seems probable that the action of the milk glands are greatly modified by the nervous condition of the animal at the time of milking as well as by the stimulus derived from manipulation of the teats and udder. In the following experiments I have endeavored, by varying the methods of milking and the conditions, under which it was done, to measure the effect of some of these factors upon the milk produced.

MILKING ONE TEAT AT A TIME.

Several years ago Dr. Sturtevant caused a cow to be milked one teat at a time, and had the milk from each teat analyzed. The result of these analyses is presented below:

Analysis of Milk from Different Teats.

	Weight of milk.	Total solids.	Fat.
First Trial —	*Lbs.*	*Per cent.*	*Per ct.*
Right fore teat	2	14.84	5.59
Left fore teat	1.25	13.80	4.43
Right hind teat	1.50	13.49	4.39
Left hind teat	1.25	14.30	3.84
Second Trial —			
Right fore teat	1.375	11.34	2.32
Left fore teat	1.375	11.99	3.00
Right hind teat	1.500	11.67	2.73
Left hind teat	1.625	11.13	2.13

This shows a marked difference in the quality of milk from the different quarters of the udder, and without further data we should be led as Dr. Sturtevant was, to the conclusion that the functions of the different quarters of udder were of a different nature. In order to obtain more facts upon this point, which seems to throw light upon the elaboration of milk, and for the purpose of noting whether any differences found in the teats were constant, the experiment of Dr. Sturtevant's was repeated several times at this Station. At each milking the teats were milked in a different order than at the preceding milking, so that after four milkings each teat had been milked first, second, third, and last. We will designate the different teats by the letters A, B, C, D; A being the right fore teat, B the right hind teat, C the left hind teat, and D the left fore teat. They were milked the first time in the following order: A first, B second, C third and D fourth. On the next milking B was milked first, C second, D third and A fourth, etc., each succeeding milking beginning at a different place, the order of milking always proceeding in the same direction. The milk from each teat was weighed and the fat content determined by Short's test at each milking. Only the evening milkings were made in this way. The work was done under my direction by students in the short course for last winter. An account, as written by one of their number, appeared in *Hoard's Dairyman* of May 24, 1889. The general results are presented in the following table:

Table Showing Effect of Milking One Teat at a Time.

Order of Milking....	First.				Second.				Third.				Fourth.			
	Teat.	Milk.	Fat.	Fat.	Teat.	Milk.	Fat.	Fat.	Teat.	Milk.	Fat.	Fat.	Teat.	Milk.	Fat.	Fat.
		lbs.	*p ct*	*lbs.*		*lbs.*	*p ct*	*lbs.*		*lbs.*	*p ct*	*lbs.*		*lbs.*	*p ct*	*lbs.*
1st day......	A	2.5	3.56	.089	B	2.3	3.50	.080	C	2.7	2.37	.064	D	1.7	1.95	.0332
2nd day.....	B	2.1	4.92	.103	C	3.1	6.03	.187	D	2.	4.51	.090	A	1.5	3.63	.054
3d day.......	C	3.	4.47	.134	D	2.3	4.42	.102	A	2.3	3.90	.090	B	1.7	3.16	.054
4th day.....	D	2.2	3.53	.078	A	2.4	3.60	.086	B	2.5	4.01	.100	C	3.0	3.93	.118
Average	....	2.45	4.12	.101		2.525	4.51	.114		2.375	3.62	.086		1.975	3.28	.065

The result at any single milking fully confirms those of Dr. Sturtevant, and shows a decided difference in the quality of milk from the different teats; if, however, the whole series be considered it is evident that the order in which the teats were milked is the chief factor which affects the quality of milk. If we arrange them in the order in which the milkings were richest we find that the second is the best in quality, the first is the second best, the third the third best, and the fourth the poorest. If, however, we take the average for each teat for the first four milkings, independent of the order of milking, we find that so much of the difference has disappeared that it is doubtful about there being any difference in the physiological functions of the different quarters of the udder. The average yield of milk and fat from each teat for the four milkings was as follows:

Average Yield from Each Teat.

	Milk. *lbs.*	Fat. *per cent.*
A	2.17	3.76
B	2.15	3.93
C	2.95	4.26
D	2.05	3.69

Another curious circumstance in connection with this test is that the average per cent. of fat in the milk was much less than in milk from the same cow when milked in the ordinary way, two teats at a time. A number of analyses of milk from the same cow, made shortly before and after this trial, show that the average fat content of her milk was about 5 per cent. The calculated per cent. of fat in the whole milking, when milked one teat at a time, was as follows:

	Per cent.
First milking	2.90
Second milking	5.00
Third milking	4.06
Fourth milking	3.78

If we consider the total yield of milk and of fat we find that the average per cent. of fat for the four milkings was 3.92, the range being over 2 per cent. The variations in each teat, arising from the order of milking, were for all except teat A very marked, being as follows:

	Per cents.
Teat A	3.56 to 3.89
Teat B	3.15 to 4.92
Teat C	2.37 to 6.03
Teat D	1.95 to 4.51

Tests of the same kind with another cow that usually gave milk containing about 4 per cent. of fat showed that when milked in this way only 2.7 per cent., in one case and 3 per cent. in another, a falling off of at least 1 per cent. of fat, due to milking one teat at a time.

MILKING FAST AND SLOW.

The above results naturally suggested that there might be some order of milking even when two teats were milked at a time which would give better results than any other order, and accordingly tests were made by milking first the two fore teats and then the two hind teats, and then reversing the order; by milking the teats upon one side before milking those upon the other, and by milking diagonally, also by distributing the milking over all of the teats. All of these methods gave milk of about the normal composition, and gave no clue to the cause of the variation when only one teat was milked at a time. It was observed, however, that when for any cause the milking was interrupted there was a falling off in the quality of the milk, thus suggesting that the time occupied in the milking might be the determining factor. Tests were accordingly made by milking cows rapidly (3 to 4 minutes), and by taking double that time. This showed marked results with nearly every cow tested. The following table gives the average daily yield in these trials:

Comparison of Fast and Slow Milking.

	FAST MILKING.			SLOW MILKING.		
	Milk per day.	Fat per day.	Per cent. fat	Milk per day.	Fat per day.	Per cent. fat
	Lbs.	*Lbs.*		*Lbs.*	*Lbs.*	
Daisy	23	1.294	5.62	23.6	1.032	4.41
Beauty	24.8	.998	4.04	24.4	.924	3.80
Bryant	26.8	1.146	4.27	26	.990	3.81
Roan	13	.592	4.56	12.4	.556	4.49
Doubtful	19.8	.974	4.94	20	.930	4.65
Emma	13.6	.564	4.14	13.6	.526	3.85
Queen	17.8	.754	4.26	17.4	.732	4.20
Rose	17.6	.730	4.12	15.0	.528	3.54
Sylvia	12.6	.774	6.12	13.0	.786	6.05
Total	169.0	7.826	....	165.4	7.004	
Average per cent. of fat	....	....	4.63	....	....	4.23

The above tests were continued over periods of several days with fast milking, and an equal number with slow milking for each cow, the periods being so arranged that some of the cows were milked fast while others were milked slow in order to eliminate so far as possible the influence of advanced period of lactation, of changes in weather, etc. The cows received the same kind of food upon both sides of the trial. The effect upon the yield of milk was not marked, this being about the same whether the cows were milked fast or slow, the variations being no more than might have been expected if the cows had been milked in the same way for the whole time. Other experiments have shown a very decided difference in yield of milk, but in most such cases not only has the time of milking been changed but the milker also, so that the cow was subjected to both the influence of change of milker and rate of milking. The amount of variation which these two causes combined may produce is shown by the following figures, taken from the *Jersey Bulletin* of August 14, 1889, where a cow was milked by a good milker and by a boy eight years old who occupied about two and one-half times as much time to milk her as was the case with the fast milker. The fast milker obtained on the average 10.6 lbs. of milk per milking, while the boy obtained only 8.2 lbs. as an average. In the case of our experiment the cows sometimes gave more when milked fast and sometimes more when milked slow, the average in all cases being but slightly in favor of the fast milking.

The effect upon the quality of milk was more marked, there being in every case richer milk produced when the cows were milked fast than when they were milked slow. The effect was most marked with the cows giving the most milk. The cows which were least susceptible to these changes were cows far advanced in the period of lactation that were giving but little milk when the trial was made. Calculated upon the fat yield, the gain by fast milking averaged for the whole lot of cows 11.73 per cent. Taking the three cows giving the most milk, the gain was .492 pounds of fat per day, which amounted to 16.7 per cent. The greatest difference that was found for a single cow was .262 pounds of fat, which was a gain of 25.38 per cent. Whenever a change was made from fast to slow milking, or the reverse, the effect in almost every case was immediate and marked. There were in all 22 changes from fast to slow or from slow to fast milking. If the yields of fat on the days preceding and following the changes are alone considered, we have for the 22 days when the cows were milked fast 20.775 lbs. of fat, for the days when the cows were milked slow 16.428 lbs. of fat, a loss for slow milking of 4.347 lbs. or 20.9 per cent. For two or three days afterward the yield of milk from the cows milked fast gradually diminished while that from the cows milked slow increased and this in a measure compensated for the immediate effect of the change. They soon, however, reached a point where the yields of both milk and fat were quite uniform, that of the cows milked slow being a little less than when they were milked fast, with no indication that the difference would not be indefinitely maintained.

CHANGE OF MILKER.

It is a fact quite generally recognized that there is considerable difference in the efficiency of different milkers. But very few of even careful dairymen realize how much it is. An experiment at the Mississippi Agricultural College* showed a difference of 244.5 lbs. of milk in the yield of 5 cows in two weeks in favor of a good milker. The milk was not analyzed. A number of tests made at this Station, in which the fat content of the milk was determined, showed a greater loss in quality than in quantity. The milkers tested here were all supposed to be good milkers, and were not, as in the Mississippi experiment, good milkers against poor milkers. There were at different times four different cows tested. The results for each cow, calculated for a single day, are given in the following table:

Comparison of Milkers.

Milker.........	**A.**			**B.**			**C.**		
Cow.	**Milk per day.**	**Fat.**	**Pr. ct. of fat.**	**Milk per day.**	**Fat.**	**Pr ct. of fat.**	**Milk per day.**	**Fat.**	**Pr. ct. of fat.**
Daisy.........	20.2	.908	4.51	22	1.068	4.85	20	.968	4.85
Governor's heifer	15.3	.682	4.45	16.2	.772	4.75	....	......	....
Beauty.........	21	.830	3.94	23.6	1.142	4.84	18.8	.762	4.06
Gypsie.........	17.8	.702	3.98	18.2	.762	4.19	....	....	.. .. ..
	74.3	3.122	4.20	80.0	3.744	4.68	38.8	1.730	... .

These tests except in the case of the last milker continued over periods of one week with each milker. The greatest effect was always noticed at the first milking after the change was made. In sixteen changes from A to B, or the reverse, there was a difference in the yield of fat in favor of B, of 1.718 pounds, or an average of .107 pounds of fat per milking. There was not a single change that was not in favor of B. Afterwards the cows milked by A improved somewhat under his milking, and those milked by B lost, but at the end of a week there was still considerable difference in the daily yield, and I believe that it would have been maintained throughout the season. The cows were milked dry by both milkers as was shown by frequent stripping after they had finished.

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*Experiment Station Mississippi, Report 1888, p. 42.

If we compare the yields of milk from the cows milked by A, with those milked by other milkers, we find that they fell off in their yield considerably more during this season than did those milked by B and C. Of course this may have been partially due to individual differences of the cows, but from the fact that the same cows in 1888, when they were milked by a different milker did not behave in this way, it seems fair to conclude that the chief cause was the manner of milking.

METHODS OF MILKING.—MILKING TUBES VS. HAND MILKING.

Although milking tubes have never been in general use, and indeed, have rarely been used at all except in case of sore or obstructed teats when it is difficult to obtain all of the milk by hand, it is nevertheless interesting to note how they compare in efficiency with hand milking, and the following tests were made for this purpose. In the trials four of Pilling's silver milk tubes were used. In milking with them all four teats were milked at the same time, the milk from each cow being analyzed by itself except in the first trial when the milk from 3 cows was mixed. The time required for milking with the tubes in this way is not much different from that required by hand. The cows were stripped by hand after milk had ceased to flow from the tubes, but in all cases the cows were found to be milked dry. The yield of milk was, in some cases, above the average and in others below that obtained by hand. On the whole the yield was slightly less than when the cows were milked by hand. The quality of milk was invariably poorer when the tubes were used than when the cow was milked by hand. There was, however, a greater difference between the cows in this respect, some giving almost as rich milk when milked with the tubes as when milked by hand, while with others the fat content was reduced more than 50 per cent. The following table gives the results calculated for yield per day. In the case of the first three trials, the milking tubes were used but one day. In the last three trials the tubes were used at each milking for 7 days. In the first 3 trials the cows were very much disturbed by the operation and the trial was discontinued on this account. The other 3 cows did not appear to mind it at all:

Milking by Hand vs. Milking Tubes.

	By Hand.			With Tubes.		
	Milk per day. *lbs.*	Fat. *per cent*	Fat. *lbs.*	Milk per day. *lbs.*	Fat. *per cent*	Fat. *lbs.*
1. Three cows......	60	4.22	2.531	58	2.46	1.428
2. Bessie's heifer...	14.6	7.34	1.072	10.4	3.88	.404
3. Bryant...........	20.8	5.47	1.139	17.3	1.93	.334
4. Governor's heifer.	12.2	4.75	.580	13	4.40	.572
5. Bunn............	18.6	3.37	.628	20.2	3.03	.612
6. Queen............	14.4	4.75	.684	15.2	3.72	.566
Total........	140.6	4.72	6.634	134.1	2.92	3.916

A very noticeable circumstance in this test is that in the last three trials where the cows were not disturbed by the use of the tubes, more milk was obtained when the tubes were used than when the cows were milked by hand. The quality of the milk, was however, always poorer when the tubes were used, and in no case did the increased quantity of milk compensate for the loss in quality. With the cows that were disturbed by the tubes there was, in every in stance, not only a falling off in quality but also a considerable falling off in the quantity given, showing that a nervous condition of the animal at the time of milking has a very marked effect on the total amount of fat produced.

Taking the eight cows tested, together, there was an average of 6.5 pounds less milk per day when the tubes were used. The loss in fat produced by the cows milked by the tubes was 2.718 pounds per day, which is 40.97 per cent. of the yield when the cows were milked by hand. Here as in all other trials which have affected the production of milk we have a much greater change in the quality than in the quantity.

Another test with the tubes deserves more than a passing notice, as it is apparently an exception to the general rule that milking tubes give poorer milk and less of it than hand milking. This test was made with Beauty, a cow that had been found very sensitive in other trials to changes in the rate of milking and also to changes in the milker. On this account a greater difference than usual in favor of hand milking was expected. A large number of analyses of milk from this cow when milked by hand showed that she usually gave milk containing about five per cent. of fat. The trial extended over only three days on the first and last of which the cow was milked by hand, on the second day she was milked with the tubes.

The yield and fat content of each milking are given below:

	Weight of milk.	Of fat.
	Lbs.	*Per cent.*
First milking, by hand	7.1	3.6
Second milking, by hand	7.1	3.6
Third milking, with tubes	7.0	4.6
Fourth milking, with tubes	5.7	4.6
Fifth milking, by hand	7.0	5
Sixth milking, by hand	5.2	5.8

This result, in favor of the milking tube as compared with the first day when the cow was milked by hand, was entirely unlooked for, but as the quality of milk on the first day was much below the average for this cow, it was quite evident that some unusual circumstance affected the cow at this time, and subsequent inquiries showed that she was on this day milked by a person not accustomed to milk her, and there is little doubt that the falling off in fat should be attributed to this. In a previous trial with the same cow a change of milker made a difference of nearly one per cent. of fat in the milk. (See page 50.) This cow was much more quiet than most cows have been when milked with tubes, and it is probable that the change in milker disturbed the cow more than the tubes.

With this explanation the result in this trial is perfectly consistent with all others that I have obtained.

CHANGE OF QUARTERS.

It is a generally accepted fact that both the yield and quality of milk is considerably affected when the cows are moved from their accustomed quarters to a strange place. This has justly made public tests at fairs and similar places unpopular with owners of fine cattle, as records made under such conditions are, almost without exception, much lower than the records made at home. This is not surprising when we consider how sensitive the cow is in this direction to any change, even in the manner of milking, and as some cows are affected more than others by changes of this kind, tests made under unusual conditions do not establish the relative merits of different cows or of different breeds.

The Station has made a single test calculated to show the effect of a simple change of place upon the yield and quality of milk, in which so far as possible the usual disturbing influences have been guarded against. For the purpose two cows from the Station herd were taken to a neighbor's barn about one mile from home. Food of the same kind that the cows were accustomed to have was taken to them, and they were fed and milked by the same person as usual, and at the same times. The intention was to maintain all the conditions as nearly as possible the same as the cows had been accustomed to, with the exception of the location, and this was as strange to the cows as if they had been taken to another state. The yield of milk and its fat content, before being moved and after, is given in the following table:

Yield and Composition of Milk.

DATE.	ROSE.		EMMA.	
	Milk.	Fat.	Milk.	Fat.
Before removal.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
April 23	15.4	.689	11.6	.504
April 24	15.4	.665	11.7	.507
After removal.				
April 25	16	.678	12.9	.522
April 26	15.5	.654	12	.588
April 27	15.3	.559	A part of one milking lost.	

When each day's milk is considered by itself, the per cent. of fat and yield per day, were practically the same as before they were taken from home. If, however, only the immediate effect, as shown by the first milking after the cows were moved, be considered, a marked result is shown:

Table Showing Each Milking on Day Preceding and Following Removal.

	ROSE.			EMMA.		
	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.
	Lbs.	*Per ct.*	*Lbs.*	*Lbs.*	*Per ct.*	*Lbs.*
Before removal—						
First milking......	7.7	4.4	.339	5.6	4.1	.230
Second milking....	7.7	4.24	.326	6.1	4.54	.277
After removal—						
Third milking.....	5.6	3.2	.179	5.4	3	.162
Fourth milking....	10.4	4.8	.499	7.5	4.8	.360

The cows were taken from home just before milking and milked directly on reaching their destination. Not only was there a falling off in the quantity of milk at this first milking, but there was a more decided falling off in the quality. The average per cent. of fat in the four milkings preceding their removal was for Rose 4.40, for Emma 4.44. For the first milking after removal it was for Rose 3.2, for Emma 3. For the next three milkings the average for Rose was 4.45, for Emma 4.65. In spite of the great falling off at the first milking its effect was more than compensated by improvement on the following days, so that in the aggregate there appears no loss from change in place. It must be remembered, however, that in moving these cows every precaution was taken to prevent other influences than that incident to the change of quarters, and the results would not apply to public tests where many disturbing factors are of necessity introduced. I believe at fairs and other public places where tests have been attempted that in general the falling off is greater than is shown above, and that the cows will not recover as rapidly as in this case, if indeed, they recover at all, while they are in contact with strangers.

THE EFFECTS OF DEHORNING UPON THE COMPOSITION OF MILK.

In the fifth annual report of this Station Mr. Short has considered the effect of dehorning upon milk production, the results of his experiments being that there was scarcely any change either in yield of milk or its quality. In his experiment the cows were dehorned before noon, several hours before milking, so that they had considerable time to recover from the excitement occasioned. Moreover, in his case, analyses were only made of the mixed morning's and evening's milk, so that any influence upon the first milking after the operation might have been compensated for by the second milking, and no change appear even if the immediate effect had been considerable. From what has already been shown concerning the susceptibility of a cow to very slight changes in the conditions under which the milking is performed, it is probable that the effect of dehorning upon the milk would be most marked if the cow were milked immediately after the operation and while she was still excited by it. An opportunity for testing this was offered this last spring when it was decided to dehorn the remainder of the Station herd. There were at this time ten cows to be dehorned, all of which were giving milk. The cows were dehorned April 24th, in the evening, just before milking. All of the cows were dehorned before any of them were milked. The time intervening between the dehorning of the first cow and the beginning of the milking was about one half an hour. The following cows were operated upon:

Description of Cows.

Name of Cow.	Breed.	Age.	Last Calf.
Topsy	Grade Holstein	9 years	Oct. 15, 1888.
Queen	Grade Jersey	7 years	Nov. 2, 1888.
Daisy	Grade Jersey	8 years	Jan. 30, 1889.
Gypsie	Grade Shorthorn	9 years	June 25, 1888.
Roan	Native	10 years	June 22, 1888.
Dolly	Grade Jersey	8 years	Nov. 1, 1888.
Purcell	Native	10 years	In 1887.
Governor's Heifer	Grade Jersey	5 years	Dec. 31, 1888.
Bessie's Heifer	Grade Jersey	5 years	May 6, 1888.
Doubtful	Grade Jersey	5 years	Jan. 9, 1888.

The yield of milk for the two days before and after the operation, together with the per cent. of fat in the milk, for the day before and the two days following, is presented in the table below:

Yield and Composition of Milk Before and After Dehorning.

DATES.	TOPSY.		QUEEN.		DAISY.		GYPSIE.		ROAN.		DOLLY.		PURCELL.		GOVERNOR'S HEIFER.		BESSIE'S HEIFER.		DOUBTFUL.		TOT'L
1889.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	
Before Dehorning.	*Lbs.*	*Pr ct.*	*Lbs.*	*Pr ct.*	*Lbs.*	*Pr ct.*	*Lbs.*	*Pr ct.*	*Lbs.*	*Pr ct.*	*Lbs.*	*Pr ct.*	*Lbs.*	*Pr ct.*	*Lbs.*	*Pr ct.*	*Lbs.*	*Pr ct.*	*Lbs.*	*Pr ct.*	*Lbs.*
April 22, P. M.	10.5	.....	8.3	......	8.8	......	9	......	5.6	......	4.9	......	4.5	......	7.6	... ..	5.5	......	8.2	......	
23, A. M.....	9.9	......	7.7	......	9.6	......	8.5	......	4.6	......	5.5	......	4.8	......	6.8	......	5.3	.....	8.7	......	
23, P. M......	10.3	4.3	7.4	4.4	9.8	4.7	8.3	4.04	5.6	4.5	5.5	5.7	4.5	4.3	7.7	4.44	5.4	8.6	8.2	4.64	
24, A. M. ...	11.2	4.2	8.4	4.4	9.1	4.04	8.5	4.	3.5	3.8	5.6	4.4	4.5	4.54	7.5	4.34	5.	10.8	9.	4.6	
Total....	41.9	... ..	31.8	......	37.3	......	34.3	.....	19.3	......	21.5	......	18.3	......	29.6	......	21.2	.....	34.1	......	289.3
After Dehorning.																					
April 24, P. M......	8.1	3.94	7.2	3.8	9.1	4.64	6.	2.74	3.7	3.64	5.3	4.84	3.7	3.64	7.1	4.64	4.8	6.54	7.6	3.74	
25, A. M.....	7.7	4.84	6.5	4.54	9.1	5.1	6.7	5.4	4.1	4.8	5.	5.4	3.4	3.4	6.8	4.64	4.4	8.	6.8	4.5	
25, P. M......	8.4	5.94	5.3	5.3	7.8	5.8	5.7	5.3	3.4	6.14	4.	6.64	3.4	4.	6.1	4.8	3.2	7.74	7.	4.8	
26, A. M.....	8.9	4.2	7.4	4.44	10.	4.64	7.7	3.8	3.4	5.	4.7	5.5	3.6	4.	7.3	4.2	4.7	6.3	8.5	4.24	
Total....	33.1	. ...	26.4	......	36.	......	26.1	......	14.6	......	19.	......	14.1	......	27.3	......	17.1	...	29.9	......	243.6
27 and 28.....	41.6	.. ...	32.5	......	39.4	......	32.1	......	16.1	......	21.1	......	14.3	......	28.2	......	19.8	......	35.3	......	280.4

There was a very marked difference in the behavior of the different cows, some of them being scarcely effected, while with others the effect was decided. With all the cows that fell off either in yield or quality, there was at the following milking an improvement, this being more marked in the per cent. of fat than in the yield of milk. In some cases this was sufficient to entirely obscure the immediate effect. The same tendency was observed in Short's experiment, in which the falling off in the milk was more than compensated for by improved quality, so that, although giving less milk in the week following dehorning, the total yield of fat was larger than before. It is probable that the slight fever which followed the operation, as shown by the temperature of the animal, may have caused the milk to be somewhat richer in fat. That something of this kind may occur is shown by tests made at the New York Experiment Station, at Geneva, of milk from cows that had been upon the cars for two or three days, the first milking afterwards being abnormally rich. In another case when cows had become feverish from improper food a similar effect was produced. In the dehorned cows, whatever the cause may have been, the effect was not permanent, both the yield and quality having reached the normal amount by the end of one week, by which time also the temperature of the animal had become normal.

It is interesting to note in this connection, the effect of excitement caused by dehorning upon other cows that were in the stable when the operation was performed. A few of these cows were where they could see the operation, while others only came in contact with the dehorned cows after the horns were removed. None of the cows bellowed when the horns were being removed, and only two of them (Roan and Queen) struggled violently. The feed for all of the cows was the same, and no cause is known which would affect the yield of milk except sympathetic excitement caused by contact with the dehorned cows, and yet the milk yield of these cows was diminished almost as much on the evening that the dehorning was done as was that of the dehorned cows. On the following morning these cows gave about their usual amount of milk. This is shown in the following table:

Yield of Milk from Cows not Dehorned.

	Palmer.	Sylvia's Heifer.	Sylvia.	Beauty.	Mattie.	Bunn.	Bessie.	Bryant.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
April 23, P. M...	7.7	7	5.7	9.4	10.5	9.7	7.5	9.9
24, A. M...	7.1	6.5	6.1	10.2	11.6	11.1	7.2	11
24, P. M...	6.5	6.2	5.2	9.2	9.8	9.1	6.5	9.3
25, A. M...	6.5	8	6.5	10.3	12	9.7	8.2	11

Usually when cows have been dehorned at the Station, the operation has been performed in the morning, several hours before the next milking. By examining the milk yield for the milking following, we find no falling off in the yield for the cows not dehorned, showing that, in those cases, any excitement occasioned by the dehorning had either subsided or had failed to produce the result corresponding to that in the experiment mentioned above. The fact seems to be that excitement of this kind rapidly subsides, and does not affect the yield of the cow if she has become quiet before milking.

A consideration of the results obtained in these experiments, leads to the following

CONCLUSIONS:

The elaboration of milk does not proceed at a uniform rate from milking to milking, but is most active at the time of milking, and is dependent not only upon the stimulus which the milk glands derive from the manipulation of the teats and udder, but upon the nervous condition of the animal at the time of milking.

In consequence of this, slight changes in the conditions under which the milking is done may have a decided influence upon both the yield and quality of milk. As a general rule the quality of milk, measured by the per cent. of fat which it contains, is more sensitive to changes of this kind than is the yield of milk. Among the changes which appear to have most influence in this respect, [illegible] lowing are of especial importance, viz.: Change in the interval between milkings and in the rate of milking; change of milkers and manner of milking, especially if the manipulation of the teats and udder be different; change of environment and any circumstance which excites or even slightly disturbs the animal at the time—excitement between milkings, if the cow has become quiet before milking, appears to have comparatively little influence. As would be expected there is a great difference in cows in this respect, some being very sensitive, while others are scarcely affected at all. In our experiments cows that have been giving milk for a long time have been less sensitive in this respect than fresh cows that were giving a large quantity of milk, but this may have been due to individual characteristics of the animals tested and not to the advanced period of lactation. I would recommend, therefore, in order to obtain the best results from any cow that first of all she be treated kindly, all sources of excitement being avoided so far as possible. She should also be fed and milked at regular intervals, by the same person, and all conditions should be maintained as nearly uniform as possible at all times. It is my opinion that kind treatment and pleasant surroundings will have a greater influence upon the quality of milk than the kind of food, provided that the ration given contains sufficient nutriment for the maintenance of the animal.

FIBRIN IN MILK.

S. M. BABCOCK.

In a paper read before the Society for the Promotion of Agricultural Science, at the Cleveland meeting, 1888, I announced the discovery of fibrin or an analogous substance in milk. In Bulletin Eighteen from this Station, the subject is presented more fully, and its bearing upon the creaming of milk especially considered. A number of experiments, made since the publication of the above mentioned articles, fully confirm the conclusions then made. On account of the limited space which this Report allows it is not thought advisable to reprint the whole of the discussion here, and accordingly only the chief points are mentioned.

PROPERTIES OF FIBRIN.

Fibrin is a nitrogenous substance found in blood shortly after it is removed from the body, and to it the spontaneous coagulation of blood is due. It is not formed in the living organism, except, under certain abnormal conditions, when the circulation is obstructed. The coagulation of blood is facilitated by warmth, by exposure to air, and by contact with foreign substances, especially if such substances have a rough surface. The coagulation begins at the surface and at the sides of the vessel containing it, and gradually extends throughout the whole mass. Under the microscope the clot has a thread-like appearance, the threads crossing each other irregularly, forming a fine network.

The coagulation of blood is retarded by cold and prevented by rapid freezing, the coagulation, however, takes place if the blood be again warmed. The coagulation may also be prevented by certain chemical re-agents, among which may be mentioned the caustic alkalies, magnesium sulphate and potassium nitrate. The clot when formed is insoluble in water, it is soluble in very dilute acetic, muriatic and lactic acids. It rapidly decomposes when exposed to the air, a substance being formed which is similar to albumen, it being soluble in water and coagulated by heat.

Freshly coagulated fibrin decomposes the peroxide of hydrogen rapidly, oxygen being set free. This power is weakened by prolonged exposure of the fibrin to air, and is destroyed when the fibrin is exposed for a short time to heat which approaches the boiling point of water.

The evidence that fibrin is formed in milk, may be summed up as follows:

1st. The peculiar grouping of the fat globules shortly after the milk is drawn, this grouping being entirely analogous to that of the blood globules in blood. When milk is first drawn the globules are entirely separate, and if the milk be received in a vessel containing a substance that will prevent the coagulation of fibrin, no grouping of the globules will occur. See Fig. 1 and 2. Fig. 1 shows the appearance of normal milk a short time after it is drawn. Fig. 2, milk to which a little caustic soda was added to prevent the coagulation of the fibrin.

2nd. The decomposition of the peroxide of hydrogen by milk, this action not taking place with milk that has been heated to near the boiling point.

3rd. The general phenomena of the creaming of milk. Those conditions which are opposed to the coagulation of fibrin being the ones which give the most efficient creaming.

AMOUNT OF FIBRIN IN MILK.

There is no method for determining very small amounts of fibrin with accuracy, so that we can only approximate the amount in milk by comparing its action with blood in which the amount of fibrin is known. Blood contains on the average about three-tenths of one per cent. of fibrin, and when diluted to two thousand times its volume with water it decomposes the peroxide of hydrogen more actively than milk, but blood contains other principles besides fibrin that have this action, so that this fact gives but little clue. If blood be diluted with five hundred volumes of water, a perceptible clot will form upon standing, which has sufficient firmness to imprison small bubbles of air and prevent their rising to the surface. These bubbles are often grouped in a manner analogous to the fat globules in milk.

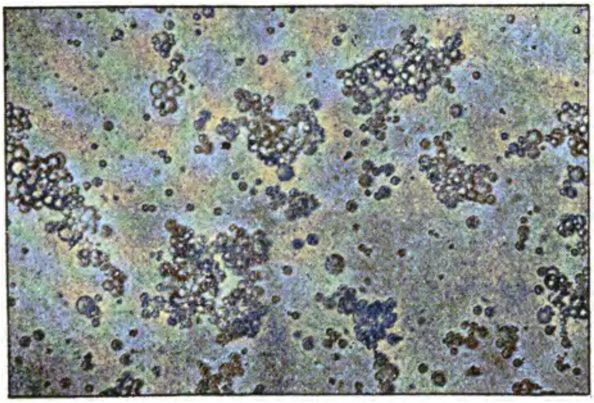

Fig. 1.

By comparing in this way diluted blood with milk I am inclined to believe that normal milk on the average contains less than one thousandth as much fibrin as blood, or about two ten thousandths per cent.

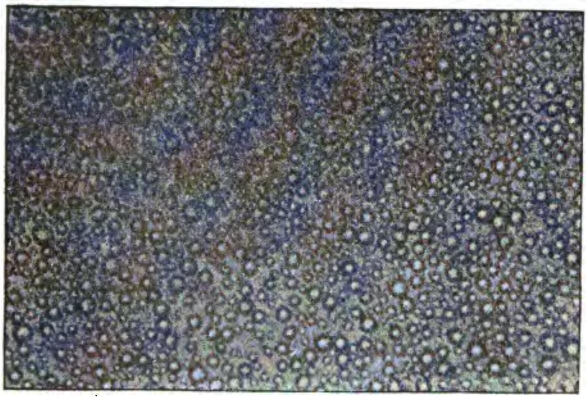

Fig. 2.

The relative amount of fibrin in different milks may be closely approximated by measuring the oxygen set free when an excess of peroxide of hydrogen is added to them. Normal milk when treated in this way will on the average liberate about one-third of its volume of oxygen. Colostrum milk, and sometimes milk from diseased cows, will set free as much as five times its volume of oxygen. If much more fibrin than occurs in colostrum milk is present the milk will coagulate spontaneously without becoming sour. Samples of milk are often met with that have this property. During the past year I have examined two samples of such milk and in both cases when treated with peroxide the evolution of oxygen was so rapid that it could not be measured in the apparatus as arranged for other milks. I would judge that the oxygen set free was from thirty to forty times the volume of milk taken. Other milks, that were quite ropy, liberated from eight to ten times their volume of oxygen. Examinations of milk for fibrin, by this method, made during the past summer show it to be a most sensitive test for abnormal milks, especially when they arise from garget or other inflammation of the udder. In two cases that have occurred in the Station herd the milk was found to contain from three to four times the usual amount of fibrin, at least one week before anything wrong was noticed by the milker, or by those handling the milk. In suspected cases of this kind a test for fibrin would be very likely to determine it before the trouble was too far advanced to be readily checked by remedies.

There appears to be no definite relation between the amounts of fat and fibrin in different milks, although cream always contains more than the milk from which it is derived, and skimmilk has scarcely any. This results from the fat globules being entangled in the small clots formed. The clots are thus floated and become incorporated with the cream.

INFLUENCE OF FIBRIN UPON THE CREAMING OF MILK.

As the clots of fibrin are in themselves heavier than water and become attached not only to the fat but to other solid matters in the milk, and often to the sides of the vessel in which the milk is set, it is evident that even the small amount of fibrin present in milk may be a great hindrance to a thorough creaming. If this is true we would expect that the most efficient creaming would be obtained when the conditions are such as to oppose the coagulation of fibrin. This I believe is always the case, at least all improvements that have been made in the efficiency of creaming have been in this direction. The centrifugal is the only exception, and this accomplishes the same end by making the effective difference between the weight of the fat and the fibrin clots so great, that they are to a considerable extent separated. In consequence of this separation we find that the centrifugal cream contains less fibrin than cream from other methods.

The most rapid and efficient creaming that I have ever obtained has been accomplished by adding such chemicals as prevent the coagulation of fibrin to perfectly fresh milk, and if such substances can be obtained that will neither effect the quality of the skimmilk nor the butter, the yield may be very much increased over that by present methods of setting. But at present the use of chemicals cannot be recommended in practice, and it is only alluded to here on account of its direct and important bearing upon the question of the existence of fibrin in milk.

The centrifugal appears to offer the best means for avoiding these difficulties, as the fibrin clots have but little influence upon its efficiency, but its expense will for a long time make its use impractical with small dairymen. For them some method of setting seems to be a necessity, and all things considered the methods of deep setting with ice or cold water offer the most advantages. Its good points are, 1st, that comparatively little surface is exposed; 2nd, that the milk is quickly cooled to a point where fibrin clots do not readily form, this being especially the case in contact with the vessel where the clots will do most harm; 3rd, that the creaming will be practically accomplished between milkings so that the same vessels may be used again; 4th, that it is economical of space, and 5th, that the first cost is low. To obtain the most efficient creaming by this method it is essential that the milk be strained directly into the can and that this be set immediately in ice water and not again disturbed until ready to skim. The thorough aeration of milk immediately after milking is frequently recommended for preservation of the milk and for the removal of animal odors, and there is little doubt that the practice is efficient for this purpose, but it operates against the creaming, and is not necessary in the making of butter, if the cows are healthy, are given proper food and are milked in a clean, well-ventilated stable. If, however, milk is to be sold for domestic purposes, or used in the manufacture of cheese the practice is always advisable as it contributes to the keeping qualities of the milk and delays the separation of cream.

It is not probable that the influence of fibrin ends when the creaming is completed, and it appears to me to be one of the chief factors which affect the churning of cream. As has been stated, much of the coagulated fibrin accumulates in the cream and encloses in its clots a considerable portion of the fat globules. These clots have practically the same effect as would a true membrane covering the globules, and must be removed before the globules can unite in the form of butter. This is accomplished by the ripening of cream, the slight acid formed being an excellent solvent for them. The acid is undoubtedly the chief cause for the increased yield of butter from ripened cream, as the addition of acid to sweet cream before churning will give the same yield of butter as if the cram were ripened in the natural way.

DIGESTION EXPERIMENTS WITH CORN ENSILAGE AND FODDER CORN.

F. W. WOLL.

Summary and Results of the Experiments:

Two feeding experiments were conducted for the purpose of ascertaining the relative value of corn ensilage and fodder corn for milk and butter production, and also to determine the digestibility of Indian corn after it has passed through the field-curing process, or through the siloing process. The first experiment is a continuation of a similar experiment conducted by the writer last year, and described in the Fifth Annual Report of the Wisconsin Experiment Station.

In the first experiment two cows were fed for a time of seventy-six days, divided into three periods; first period lasting three weeks, and the other periods lasting four weeks each. During the whole experiment each cow received daily ten pounds of bran and two pounds of corn meal; in addition to this feed, they were fed corn ensilage ad libitum during the first and the last period, and dry fodder corn, from the same field, and cured in the field, during the second period, this feed being also fed ad libitum. To trace the influence of the feed on the composition and yield of milk and milk components, and of butter and butter fat, chemical analyses were made daily of the milk given by each cow; the milk from each cow was set separately, and the cream churned by itself. Chemical analysis was made of every sample of butter made, and, during the latter part of each period, of the skimmed milk and butter milk. In order to obtain information concerning the digestibility of the rations fed, the excrements from the cows were collected during the third week of each period (second week of first period). The number and relative size of the fat globules in the milk from each cow were determined in each period, to ascertain if the feed in any way could change the microscopical appearance of the milk, and thus modify its value for butter production. Of the results obtained in the experiment the following are considered the main ones:

The milk yield decreased on the fodder corn feeding, as did also the total daily production of milk solids, fat and casein with both cows. The cows were able to derive more nourishment from the ensilage feed than from the fodder corn feed; considering this fact in connection with the preceding one we find that, for every pound of digestible matter in each ration they produced slightly more milk on the fodder corn feeding, and practically similar quantities of milk components. The churning qualities of the milk fat did not seem to be influenced materially by the feed, while the number of fat globules in the milk decreased, and their relative size increased on the fodder corn feed. As in last year's experiment, the ensilage rations were slightly more digestible than the fodder corn ration.

The second experiment conducted during last season was a digestion experiment with the two feeding stuffs, corn ensilage and fodder corn, of same variety and grown under similar conditions. Two cows were used for the experiment. Their milk, butter, skimmed milk and butter milk were analyzed as in the preceding experiment. Similar microscopic work was done on this experiment, as in case of the preceding one.

As a result of the experiment it was found, that the ensilage was somewhat more digestible than the fodder corn; 60 per cent. of the dry matter of the fodder corn was digestible, while 63 per cent. of the same component was digestible in the ensilage; of the crude protein 49 and 54 per cent. were digested, in case of fodder corn and corn ensilage, respectively. The churning qualities of the milk were improved with 4 per cent., while the fat globules increased in number and decreased in size on the ensilage feed,—a similar result as was found in the preceding experiment. It was further found, in both experiments, that with the advance of the period of lactation of the cows, the number of fat globules increase, at the same time as they are growing constantly smaller in size. This explains the difficulty that is often found in the creaming and churning of strippers' milk.

In the following pages a more detailed description of the two experiments is given:

On pp. 28–63, of the Fifth Annual Report of this Station, an account is given of an experiment conducted by the writer for the purpose of ascertaining the influence of corn ensilage and dry fodder corn on the quality and quantity of milk. Last winter the experiment was repeated on a somewhat modified plan, and a digestion experiment was also conducted with corn ensilage and dry fodder corn, from the same field and cut at the same time. These experiments will be described and discussed in the following pages, only averages and summaries being here given and considered. The detailed data on the experiment will be published later in our scientific press.

FIRST EXPERIMENT, 1888-89. CORN ENSILAGE vs. DRY FODDER CORN, FOR MILK AND BUTTER PRODUCTION.

GENERAL PLAN OF EXPERIMENT.

The experiment was divided into three periods; the first period lasted three weeks, and the second and third period, four weeks each; a week's preliminary feeding preceded the experiment proper. During the first and third period Smedley Yellow Dent corn ensilage was fed, and during the second period, cut dry fodder corn of the same variety. In addition to this feed the two cows experimented on received the same amount of bran and corn meal throughout the experiment.

The plan of the experiment differed from that of last year's experiment in so far that the cows received the ensilage and the fodder corn in such quantities as they wanted them, while last year a definite quantity of each fodder was given. In this case, the result shows how well the cows can do on an equal amount of dry matter (or nearly so) in ensilage and on fodder corn; in the other case, they are allowed to follow their own tastes and will do as well on each feed, as this is adapted for them. The milk was weighed and analyzed daily; the digestibility of the rations was determined during the second week of the first period, and the third week of the other two periods.

ANIMALS USED IN THE EXPERIMENT.

The following table gives the necessary information in regard to the cows used in the experiment:

Name of cow.	Breed.	Age.	Time of last calving.	Initial weight.	Notes.
Sylvia	High grade Jersey	8 yrs.	1888. Nov. 14	875 lbs.	Served Dec. 11; re-served Jan. 4.
Topsy	High grade Holstein	7 yrs.	Oct. 15	1044 lbs.	Served Nov. 29.

FEEDING STUFFS.

The corn ensilage used in the first and third period of the experiment was made from Smedley's Yellow Dent corn.

In preparing the coarse fodders for this experiment a plan was followed similar to that used at this Station in previous years. The fodder was cut, and alternating loads were filled into the silo and put in shocks in the field. The green fodder prepared for the silo or shocked was thus of the same kind and maturity, and as nearly alike in chemical composition as could be arranged. The fodder was planted on well prepared and manured land, in rows four feet apart; there was on an average a stalk every seven inches in the row; at the time of filling, it was ten feet tall, and the earliest ears were commencing to dent. The silo was filled September 4 and 5, by rapid filling; in all 15,288 bs. were put into the silo; 12,151 lbs. of good ensilage were obtained from the silo; a small portion of the fodder on top had spoiled; the temperature in different layers and places in the silo was carefully observed in the same way as last year.*

The highest temperature in the silo was observed one foot from the wall, two feet below the top of the ensilage, being 131° F. On opening the silo, November 19, the temperature in the lower tubes had fallen to 59° near the wall, and 73°.4 F. in the center, three feet from the bottom of the silo, and 100.°4 and 104° F. near the wall and in the center, respectively, two feet from above. The ensilage was of superior quality, of a pleasant aromatic odor. The loss during the siloing process proved to be by chemical analysis, 12.87 per cent. of dry matter and 5.20 per cent. of crude protein. Both ensilage and fodder corn were unhusked.

The shocked corn was left in the field till October 8, and then (thirty-four days from the day when it was shocked) transferred to the barn, where it was stored on the upper floor; it was then in a very dry condition, so that care had to be taken to prevent the leaves from breaking in handling.

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* Fifth Annual Rep. Wis. Agr. Exp. Sta., p. 30.

The corn meal and bran used on the experiment were bought in the local market; the latter was made by the roller process.

COMPOSITION OF FEEDING STUFFS.

The following table gives the chemical composition of the feeding stuffs used in the experiment:

	Fodder corn.	Corn Ensilage.		Roller Bran.	Corn meal.
Station No.	593	564	611	598	598
	Pr cent.	*Pr cent.*	*Pr cent.*	*Pr cent.*	*Pr cent.*
Moisture	32.29	72.47	72.37	14.55	19.96
Dry matter	67.71	27.53	27.63	85.45	80.04
Dry matter contained—					
Ash	5.70	5.25	4.92	6.24	1.57
Ether extract	2.77	4.06	3.39	4.35	3.27
Crude fiber	25.74	26.56	25.72	9.07	2.32
Crude protein	9.06	8.19	7.72	16.41	10.43
Sugar (Glucose + invert sugar)	5.40	3.96	2.64	5.22	2.88
Starch, gums, etc.	51.33	51.98	55.61	58.71	79.53
	100.00	100.00	100.00	100.00	100.00
Albuminoid N	1.17	1.00	.86	2.10	1.66
Amide N	.28	.31	.38	.53	0.00
Per cent. Amide N	19.32	23.72	30.77	20.19	....

The ensilage contained 1.05 per cent. total acid, see Bulletin No. 19, Wisconsin Agricultural Experimental Station.

METHODS OF CONDUCTING THE EXPERIMENT.

The experiment was conducted in a way similar as to that of last year. Account will here be given only of points where the manner of proceeding was changed.

The milk was analyzed daily for solids and fat throughout the experiment, and the viscosity of the milk and its specific gravity were also determined daily, during the last two weeks of each period; besides this, the casein and ash of the milk were determined, thus giving a complete analysis of the milk during these weeks.

The milk from both cows was set separately in Cooley cans (deep setting system); the skimmilk drawn off after twelve hours and weighed; during the last two weeks of each period it was carefully sampled daily and analyzed for solids and fat, and its viscosity and specific gravity were also determined. In order to study the influence of the feed on the size and number of the fat globules of the milk, both whole and skimmmilk were subjected to microscopic examination during the last week of each period, and the number of fat globules as well as their size were determined.

The cream from each cow's milk was churned by itself, two churnings being made each week at intervals of three and four days, alternately. Exact records of all data of the churning were kept; the butter was weighed and carefully sampled, and every sample was analyzed for water and fat. During the last two weeks of each period the buttermilk was also sampled and analyzed for solids and fat, the object being during this part of each period to obtain complete data concerning the distribution of fat in the milk, skimmilk, butter milk, and butter, on different feeds.

The solid and liquid excrements were collected during the first six days of the weeks mentioned above, and weighed on a platform scale, the same one used for the weighing of the milk (sensitive to .05 of one pound).

All chemical work done, and the planning and supervision of the experiment, as well as the collection and discussion of the data obtained, are the work of the present writer.

The following summary may be of some interest in this connection, as showing the amount of labor necessary in investigation of this kind:

Summary of Experiment.

Experiment lasted	76 days.

Weighings

Of cows	154
feed	984
refuse feed	47
water drunk	144
dung	36
urine	36
whole milk	308
skimmed milk	308
butter	44
Total	2,061

Temperatures Taken.

Of stable	231
cream	88
Total	319

Chemical Analyses.

	Samples.	Single Determinations.
Of fodders	41	129
whole milk	154	698
skimmed milk	84	336
buttermilk	22	44
butter	44	88
dung	6	42
urine	36	72
Total	387	1,409

Microscopical Work.

No. of fat globules determined in whole milk	36
No. of fat globules determined in skimmed milk	36
Total	72

The experiment proper began November 28, 1888, and lasted until February 12, 1889; the preliminary feeding began November 21, 1888.

RATIONS FED.

The cows were fed the following rations per day in the different periods:

Period I and III.		*Period II.*	
Bran	10 lbs.	Bran	10 lbs.
Corn meal	2 lbs.	Corn meal	2 lbs.
Corn ensilage	ad libitum.	Fodder corn	ad libitum.

In addition to this feed, the cows received 20 grams (about 2–3 oz.) of salt per head per day, in two portions, sprinkled over the coarse feed. The farm hand attending to the cows watched them closely as to their appetites, and fed the ensilage or fodder corn in such quantities as he thought they would eat up clean; in this way the cows obtained all the food they would eat, but as a rule no more. The ensilage fed was always eaten up clean, some of the fodder corn, on the other hand, was left uneaten. The uneaten portion was weighed back, sampled and submitted to chemical analysis.

In discussing the data obtained on the experiment, much the same plan will be followed as in the discussion of last year's experiment, of which this one is a continuation or parallel. It is, therefore, not thought necessary always to explain the why and the wherefore of deductions drawn, or discussions entered into. These are either explained by the context or in last year's work.

We shall first consider the temperature of the stable during the experiment; the temperature was observed three times a day, at 7 A. M., 1 P. M. and 8 P. M.

Average Temperature of the Stable in Degrees Centigrade.

	Whole period.	Last two weeks.
Period I	10.0	9.8
Period II	8.0	7.8
Period III	4.8	3.9

The average of the temperature for the ensilage periods is 7°.4 or 0°.6 lower than the temperature for the fodder corn period. Considering only the last two weeks of each period there was a difference of 0°.9 C. in favor of the fodder corn period. Either of these differences is, however, too small to receive much consideration; they lie within 2 degrees Fahrenheit.

Live Weight and Water Drunk (in pounds).

		SYLVIA.		TOPSY.	
PERIOD.	Week.	Live weight.	Water drunk.	Live weight.	Water drunk.
I	1	859.7	62.9	1037.2	69.0
	2	851.8	56.5	1033.9	69.7
	3	841.7	56.6	1046.0	67.7
II	1	822.4	81.9	987.9	98.7
	2	833.0	74.6	1000.8	98.9
	3	820.6	68.4	990.1	95.9
	4	817.9	68.5	993.9	94.6
III	1	836.2	49.4	1054.0	62.0
	2	843.6	46.5	1050.1	65.7
	3	845.8	49.5	1053.9	69.5
	4	832.7	46.5	1016.4	68.0

Considering the last two weeks of each period, we have the following table:

Average Live Weight and Water drunk for each Period, in pounds.

	SYLVIA.		TOPSY.	
	Live weight.	Water drunk.	Live weight.	Water drunk.
Period I	846.8	56.6	1,040.0	68.7
Period II	819.3	68.5	992.0	95.3
Period III	839.3	48.0	1,035.2	68.8
Mean of period I and III	843.1	52.3	1,037.6	68.8
Difference.	— 23.8	+16.2	—45.6	+26.5

The last line in the table gives the differences between the actually observed data for the second period, and the mean figures for periods I and III.

We observe here the same point as attention was called to in last year's experiment, that succulent foods increase the live weight of the animals, and that this increase is in no way due to increase in flesh, for reasons explained in the discussion of last year's experiment. Along with the decrease of live weight on dry feed goes an increase in the water consumed, as would be naturally supposed.*

GENERAL CONDITION OF THE COWS.

The cows practically held their own during the experiment, as will be seen from the last table. The value of a fodder as a cattle food is dependent in no small degree upon its palatability. This is especially noticeable, when ensilage and dry fodder corn are compared; the cows take to the former with far better appetite, and relish it in every way better than they do fodder corn. Following their own instinct, the cows on this experiment were able to consume more dry matter in their food on ensilage than on fodder corn; as will be seen at a glance from the following table. While the cow Topsy thus could consume more than seventy pounds of ensilage per day in addition to her grain feed, she did not want more than twenty-five pounds of fodder corn, and left, as a rule, a portion uneaten. The experiment did not seem to affect the cows in any bad manner, in spite of the monotonous feed they had to put up with, and the confined condition during part of the experiment. Toward the end of the last period, owing to the poor quality of the ensilage then on hand, the cows did not do as well; and Topsy showed signs of scouring. This accident excepted, the experiment went through in a most successful and satisfactory manner, making, as it is thought, the results obtained trustworthy and valuable.

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* Fifth Annual Report of this Station, p. 36.

FOOD CONSUMED.

In considering the effect of any food on milk production, it is necessary to take into account the quantity of dry matter given in the food. By *dry matter* we understand everything which goes to make up the fodder except water. It is further necessary to know, how much of the dry matter is really of value to the animal; how much is digested. This portion of the food is taken up into the system and utilized in maintaining the functions of the animal, and in case of milch cows, provides the required nourishment for milk production. Below will be found a table, giving the total dry matter fed in the different weeks of each period, and the total digestible matter in each week's ration. The latter was determined directly during the weeks when the excrements were collected, and in the other weeks, calculated from the digestibility coefficients thus found for the different rations, and for each cow. The following table also gives the number of pounds of coarse fodder eaten by the cows in the different periods:

Food Consumed per Day in Pounds.

Period.	Week	ENSILAGE.		FODDER CORN		BRAN.	CORN MEAL.	Total dry matter.	Total digest'ble matter.
		Am't eaten.	Dry matter.	Am't eaten.	Dry matter.	Dry matter.	Dry matter.		
					SYLVIA.				
I......	1	53.1	13.86	......	......	7.99	1.74	23.59	15.13
	2	48.2	13.26	......	......	8.67	1.76	23.69	15.22
	3	47.1	12.34	......	......	8.61	1.75	22.70	14.55
II.....	1	2.7	.71	17.3	12.04	8.62	1.61	22.98	14.45
	2	......	......	19.2	11.62	8.55	1.63	21.80	13.71
	3	......	......	15.4	10.54	8.55	1.60	20.69	13.04
	4	......	......	15.1	10.53	8.51	1.60	20.64	12.98
III....	1	42.6	11.14	1.0	.69	8.52	1.61	21.96	14.35
	2	46.4	11.16	......	......	8.64	1.62	21.42	14.00
	3	44.4	12.27	......	......	8.58	1.65	22.50	14.73
	4	37.0	9.15	......	......	8.49	1.67	19.31	12.62
					TOPSY.				
I......	1	72.3	19.87	......	......	7.99	1.74	29.60	18.67
	2	68.2	18.54	......	......	8.67	1.76	28.97	18.45
	3	72.9	19.11	......	......	8.61	1.75	29.47	18.59
II.....	1	2.9	.76	21.8	15.16	8.62	1.61	26.15	15.95
	2	......	......	25.0	15.12	8.55	1.63	25.30	15.44
	3	......	......	24.5	16.62	8.55	1.60	26.77	16.36
	4	......	......	25.9	17.87	8.51	1.60	27.98	17.08
III....	1	70.1	18.32	1.0	.69	8.52	1.61	29.14	19.06
	2	72.4	17.42	......	......	8.64	1.62	27.68	18.11
	3	75.7	20.91	......	......	8.58	1.65	31.14	20.34
	4	58.2	14.39	... ..	......	8.49	1.67	24.55	16.06

It will be seen that the cows ate less dry matter during the fodder corn period than during the two ensilage periods, when the last week of third period is left out of consideration; during this week the amount of food eaten decreased on account of the poor quality of the ensilage.

We will now turn our attention to the effect that the food given the cows had upon the quantity and quality of the milk, and upon the yield of butter.

I. QUALITY OF MILK PRODUCED.

It is a well known fact that the maximum yield of milk from a cow comes directly after calving, and that from that time on there is a gradual depression in the milk flow. In experiments like the one under discussion, covering a period of nearly three months, this will always be noticeable. In order to ascertain the influence of the feed upon the milk yield it is therefore necessary to have the conditions at the beginning and at the end of the experiment strictly the same; especially, the rations fed must be the same; after the bodies of the animals have become adapted to the feed we are enabled to see how well they do on this feed, and by comparing the opening and closing period, we can find approximately how well they would have done, provided the feed had been the same throughout the experiment. In the following table, in the column headed *Calculated*, the figures represent the quantity of milk that would have been given on this supposition, that the milk flow had decreased at a uniform rate. While this is not absolutely true, the error introduced by this method of calculation is very small, on account of the small part of the lactation period lying within the experiment.

The milk in the different periods, and weeks of same period cannot be directly compared with one another. As will be seen later on, the composition of the milk changed considerably during the experiment, the milk of Sylvia at the end of the experiment containing 16.17 per cent. solids, while it contained only 14.57 per cent. at the beginning, and Topsy's milk in the same way varying from 12.64 per cent. solids in first period to 13.58 per cent. in the last period. To make the yield of milk in both cases strictly comparable, the milk is calculated on the basis of a content of 85 per cent. water throughout the experiment; the figures thus obtained are given in the second column of the table. From these figures are again derived the yield of milk supposed to have been given, had the feed been the same in second period as in first and last. The column headed *Difference* gives the variation between these two latter columns.

Milk Yield in Pounds.

		SYLVIA.				TOPSY.			
Period.	Week	Fo'nd	With 85 per ct water.	Calculated.	Differ'nce	Fo'nd	With 85 per ct water.	Calculated.	Difference.
I....	1	21.54	20.92	......	......	29.70	25.03	......	....
	2	21.73	20.99	20.40	+.59	30.04	25.62	24.84	+.78
	3	19.80	20.21	19.88	+.33	29.46	25.61	24.64	+.97
II...	1	18.37	18.50	19.36	—.86	27.77	24.42	24.45	—.03
	2	17.34	18.03	18.84	—.81	28.26	25.05	24.26	+.79
	3	16.81	17.44	18.32	—.88	28.19	24.30	24.06	+.24
	4	16.26	17.02	17.80	—.78	27.44	24.03	23.87	+.16
III..	1	16.27	16.97	17.28	—.31	26.61	23.83	23.68	+.15
	2	16.10	16.71	16.76	—.05	26.67	23.93	23.48	+.45
	3	15.31	16.06	16.24	—.18	26.40	23.44	23.29	+.13
	4	14.58	15.71	.....	......	25.52	23.10	......	....

Considering only the last two weeks in each period we do away with the influence of the feed in the preceding period; we then get the following average figures for each period:

Average Milk Yield per Period—in Pounds.

PERIOD.	SYLVIA.			TOPSY.		
	Calc. with 85 pr cent. water.	Average of I and III.	Difference.	Calc. with 85 pr cent. water.	Average of I and III.	Difference.
I	20.60	....	....	25.62	....	....
II	17.23	18.25	−1.02	24.17	24.45	−.28
III	15.89	....	....	23.27	....	....

On account of the fodder corn feeding we conclude that the milk yield was decreased 1.02 lbs. and .28 lbs. for Sylvia and Topsy, respectively, per day during the second period.

We shall now see how the quality of milk was influenced by the feed.

II. QUALITY OF MILK PRODUCED.

The chemical composition of the milk produced by the two cows experimented on is given in the following table. The milk was analyzed every day during the experiment, but only average figures for each week are given here. The specific gravity was taken by a New York Board of Health lactometer, and the viscosity of the milk determined by a Babcock viscometer.*

For methods of analysis of components of the milk, see *Agricultural Science*, II (1887), p. 228.

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*Report N. Y. Agr'l Exp. Station (Geneva) for 1886, pp. 316–330.

Average Percentage Composition of Milk Produced.

PERIOD.	Week	Total solids.	Fat.	Casein.	Ash.	Solids not fat.	Viscosity	Sp. Gr
				SYLVIA.				
I	1	14.57	5.24	....	......	9.33	......	1.0339
	2	14.47	5.35	3.69	.89	9.12	324	1.0343
	3	15.31	5.61	3.89	.82	9.70	361	1.0348
II	1	15.11	5.61	....	......	9.50	366	1.0345
	2	15.60	5.74	....	......	9.86	368	1.0343
	3	15.55	5.79	4.24	.82	9.76	376	1.0351
	4	15.70	5.92	4.12	.88	9.78	385	1.0347
III	1	15.65	6.06	....	......	9.59	[1]362	[1]1.0346
	2	15.57	5.92	....	......	9.65	[2]392	[2]1.0353
	3	15.74	6.03	4.13	.86	9.71	382	1.0355
	4	16.17	6.34	4.13	.83	9.83	394	1.0351
				TOPSY.				
I	1	12.64	3.88	....	......	8.76	......	1.0331
	2	12.79	4.31	2.92	.77	8.48	268	1.0330
	3	13.04	4.19	3.04	.76	8.85	265	1.0329
II	1	13.19	4.33	....	......	8.86	268	1.0332
	2	13.30	4.24	....	......	9.06	253	1.0333
	3	12.93	4.27	3.10	.76	8.66	261	1.0328
	4	13.15	4.33	3.07	.82	8.82	269	1.0330
III	1	13.43	4.59	....	......	8.84	[1]261	[1]1.0330
	2	13.46	4.61	....	......	8.85	[2]265	[2]1.0330
	3	13.32	4.51	3.08	.83	8.81	267	1.0333
	4	13.58	4.71	2.99	.79	8.87	270	1.0333

[1] Average of 5 determinations. [2] Average of 3 determinations.

When only the last two weeks of each period are considered, we get the following average figures for each period. The last line gives the difference in the composition of the milk produced on the fodder corn period, and the average of the two ensilage periods:

Average Composition of Milk per Period — In per cent.

	Solids	Fat.	Cas'in	Ash.	Solids not fat.	Viscosity.	Sp. Gr
			SYLVIA.				
Period I	14.89	5.48	3.79	.86	9.41	343	1.0346
Period II	15.63	5.86	4.18	.85	9.77	381	1.0349
Period III	15.96	6.19	4.13	.85	9.77	388	1.0353
Av. of I and III	15.43	5.84	3.96	.86	9.59	366	1.0350
Difference	+.20	+.02	+.22	—	+.18	+15	--.0001
			TOPSY.				
Period I	12.92	4.25	2.98	.77	8.67	267	1.0330
Period II	13.04	4.30	3.09	.79	8.74	265	1.0329
Period III	13.45	4.61	3.04	.81	8.84	269	1.0336
Average of I and III	13.19	4.43	3.01	.79	8.76	268	1.0333
Difference	—.15	—.13	+.08	......	—.02	—3	--.0004

As will be seen from this table, the feeding of fodder corn in the second period influenced the milk of the two cows in nearly opposite ways; Sylvia's milk was somewhat richer and Topsy's milk somewhat poorer on account of the fodder corn feeding. We will discuss this point later. In passing, attention is called to the fact that also in last year's experiment the feed influenced the composition of the milk differently in case of the two cows on the trial.

Having now considered the quantity and the quality of the milk produced on the experiment we combine these data, and investigate the total quantities of milk constituents produced per day by the cows during each period.

III. AVERAGE DAILY PRODUCTION.

Only the average figures for daily production of total solids, fat, and casein are given below, these being the more important ones. The table tells how many pounds (or parts of a pound) were produced daily, on an average, by each cow during the experiment:

Average Daily Production in Pounds.

PERIOD.	Week	Feed.	SYLVIA.			TOPSY.		
			Solids	Fat.	Casein.	Solids	Fat.	Casein.
I.....	1	....	3.141	1.130	....	3.753	1.153	....
	2	Ensilage....	3.144	1.161	.799	3.842	1.295	.876
	3	....	3.033	1.111	.769	3.819	1.226	.889
II....	1	....	2.786	1.025	....	3.665	1.202	....
	2	Fodder corn	2.705	1.016	....	3.777	1.202	....
	3		2.614	.973	.713	3.644	1.204	.875
	4	....	2.549	.961	.670	3.608	1.189	.840
III...	1	....	2.554	.987	....	3.575	1.221	....
	2	Ensilage....	2.507	.953	....	3.591	1.229	....
	3		2.403	.920	.630	3.496	1.186	.809
	4	....	2.358	.925	.602	3.463	1.199	.762

As with the yield of milk, so with the quantities of milk constituents produced; as the lactation period advances, the quantities produced decrease; the cow does her best as regards both milk yield and components of the milk, directly after the calving, and from that time there is a slow, but steady decrease. The feed may modify this decrease to a certain extent, but it can never obliterate it.

Considering the last two weeks of each peried we get, what we have called, the average data for the periods.

Average Daily Production in Pounds.

PERIODS.	SYLVIA.			TOPSY.		
	Solids.	Fat.	Casein.	Solids.	Fat.	Casein.
I....................	3.089	1.136	.784	3.831	1.261	.883
II....................	2.582	.967	.692	3.626	1.197	.858
III....................	2.381	.923	.616	3.480	1.193	.786
Average of I and III...	2.735	1.030	.700	3.656	1.227	.845
Difference............	—.153	—.063	—.008	—.030	—.030	+.013

There was a decrease in the quantities of total solids, fat and casein produced (Topsy excepted) on account of fodder corn feeding. This result might be taken to indicate that when the cows are given the choice between fodder corn and ensilage, they are able to do better on ensilage than on fodder corn, as regards the quantities of fat and solids produced in their milk. That this is no universal rule, however, but one rather dependent on the individuality of each cow, is shown by last year's experiment where results contrary to these were obtained; the ensilage period in last year's experiment showed a smaller production of total solids; of milk fat there was, in one case a smaller, in the other a larger, production on the ensilage feed, than was found in the fodder corn periods. The cow Topsy which was used on both experiments, last year produced less milk solids, milk fat and casein on the ensilage feed than on the fodder corn, while this year she produced more solids and fat, and less casein, on the former than on the latter feed.

This result evidently leads to but one conclusion, viz., given a sufficient amount of feed, the *kind* of feed is of less importance in determining the nutritive effect, than are the previous feed and the individuality of the cow.

We noticed that, broadly speaking, the nutritive effect of the fodder corn ration was somewhat inferior to that of the ensilage ration in this year's experiment. From the table on page 80 we remember that the quantities of digestible matter obtained in the different rations varied somewhat. To ascertain the capability of each food to furnish nutrients, it will be necessary to calculate, how much was produced of milk, milk solids, and fat, by one pound of digestible matter in the different rations. We shall only consider the average of the last two weeks of each period, as before, taking this mean as representing the data for each period:

One Pound of Digestible Matter Produced — in Pounds.

PER.	Feed.	SYLVIA.				TOPSY.			
		Milk.	Milk solids.	Fat.	Casein.	Milk.	Milk solids.	Fat.	Casein.
I.......	Ensilage .	1.384	.208	.076	.053	1.384	.207	.068	.048
II......	Fodder corn	1.335	.198	.075	.054	1.447	.217	.072	.051
III.....	Ensilage .	1.168	.175	.068	.046	1.296	.194	.067	.044

Taking the mean of the figures for first and third period (the ensilage periods) and comparing the quantities thus found with the figures for the fodder corn period (second period), we find how much more or less was produced by one pound of digestible matter during the fodder corn period than during the ensilage periods.

Greater (+) or Smaller (—) Production for every lb. of Digestible Matter During the Fodder Corn Period than Average of the two Ensilage Periods.

SYLVIA.				TOPSY.			
Milk.	Milk solids.	Milk fat.	Casein.	Milk.	Milk solids.	Milk fat.	Casein.
+.059	+.006	+.003	+.004	+.107	+.016	+.004	+.005

This table shows the fodder corn ration fully equal to, and as regards the yield of milk, somewhat superior to the ensilage rations in nutritive effect. For every pound of digestible matter that Sylvia assimilated on the fodder corn feed, she made .059 pounds more milk, .006 pounds more milk solids, .003 pounds more milk fat, and .004 pounds more casein in the milk, than what was produced by one pound digested from the ensilage rations. As regards the differences in the constituents of the milk produced, they are so small that we may be justified in ignoring them, when each cow is considered by herself. If a similar increase in nutritive effect should be found to hold good in case of a whole herd, it would certainly, however, make itself felt. It will be remembered that the cows obtained a somewhat larger quantity of digestible matter in the ensilage rations than in the fodder corn ration, when they followed their own tastes as regards quantities eaten. While, therefore, they were able to make more milk, and more solids and fat in their milk on the ensilage rations, still pound for pound these rations were unable to produce quantities of milk and milk constituents quite as large, as was produced by the digestible part of the fodder corn rations.

BUTTER PRODUCED.

We now come to consider the butter produced by the two cows during the experiment. As stated in the introduction, the cream obtained by deep setting system from both cows, milk, was churned every three and four days, alternating; the butter was sampled and analyzed, and during the last two weeks of each period the buttermilk was also sampled and analyzed. The object in view was to ascertain to what extent, if any, the food given the cows would influence the churning qualities of the milk fat; if, in other words, the butter milk would prove richer or poorer as regards fat content in the ensilage periods than in the fodder corn period. The butter was weighed unsalted after having been drained and worked slightly, the cream was churned at 18° Centigrade, and the temperature at the end of the churning, as well as the time required for churning, carefully noted. The melting points of the filtered butter fats were determined by Wiley's method.*

The following table gives the quantities of butter obtained in each churning, and the composition of the butter:

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*Bulletin No. 19, p. 72, U. S. Department of Agriculture, Division of Chemistry.

Weight and Composition of Butter Produced.

DATES.	SYLVIA.					TOPSY.				
	Weight of Butter.	Water.	Fat.	Casein.	Melting point of fat.	Weight of butter	Water.	Fat.	Casein.	Melting point of fat.
Period I.	*lbs.*	*per ct*	*per ct*	*per ct*	*°C.*	*lbs.*	*per ct*	*per ct*	*per ct*	*°C.*
Nov. 29–Dec. 2*....	4.69	36.92	61.23	1.85	33.9	4.63	18.47	79.90	1.63	34.2
Dec. 2–5.	4.25	20.82	77.30	1.88	34.2	4.94	23.37	74.89	1.74	34.9
Dec. 6–9	4.13	24.19	74.64	1.17	33.4	4.94	31.73	66.69	1.58	34.9
Dec. 9–12	4.75	18.93	79.53	1.54	34.6	5.06	24.70	74.12	1.18	33.7
Dec. 13–16	4.13	17.08	81.12	1.80	34.1	5.25	20.35	78.10	1.55	34.3
Dec. 16–19	4.44	24.76	73.28	1.96	34.3	5.44	20.92	77.59	1.49	34.3
Period II.										
Dec. 20–23	3.69	18.91	79.69	1.40	34.4	4.63	20.55	78.13	1.32	34.6
Dec. 23–26	3.31	20.24	78.33	1.43	33.5	4.75	17.22	81.44	1.34	34.8
Dec. 27–30	4.19	18.84	79.70	1.46	33.5	5.13	18.07	80.75	1.18	34.4
Dec. 31–Jan. 2.....	3.13	17.11	81.38	1.51	33.8	4.19	19.13	79.44	1.43	34.3
Jan. 3–6	4.13	19.34	78.54	2.12	33.9	5.50	25.69	72.67	1.64	34.2
Jan. 7–9	3.13	20.77	77.65	1.58	34.3	4.00	19.56	79.02	1.42	34.5
Jan. 10–13	3.88	18.23	79.96	1.81	33.6	5.44	21.11	77.09	1.80	34.8
Jan. 14–16	....	20.40	78.09	1.51	33.4	4.06	18.29	80.42	1.29	33.8
Period III.										
Jan. 17–20	4.44	24.56	73.27	2.17	33.8	5.75	21.87	76.73	1.40	34.6
Jan. 21–23	3.13	17.49	80.64	1.87	34.3	4.06	21.31	77.40	1.29	35.8
Jan. 24–27	4.19	18.75	80.03	1.22	34.5	5.38	21.13	77.62	1.25	35.6
Jan. 28–30	3.06	16.30	82.46	1.24	35.0	4.25	18.19	80.00	1.81	35.8
Jan. 31–Feb. 3.....	4.00	22.00	75.96	2.04	34.7	5.31	20.71	77.41	1.88	34.9
Feb. 4–6	2.50	19.31	78.98	1.71	34.8	4.06	20.23	77.94	1.83	35.4
Feb. 7–10	4.13	20.98	77.49	1.53	35.2	5.44	19.27	79.27	1.46	35.6
Feb. 11–12	1.88	20.05	79.13	.82	35.8	2.63	17.49	81.12	1.39	36.3

*From Nov. 29 to Dec. 26, churnings were made from every 3½ days' product.

By comparing the quantity of butter fat obtained in each churning with the number of pounds of fat in the milk that entered into the churning, we are able to ascertain the proportion of milk fat recovered in the butter in the different churnings, or we will find, what is called, the *churnability of the milk fat.* In the following table are given the results of these calculations. As an illustration we will take the first figure in the table. Sylvia gave in the first churning November 29–December 12, 61.23 × 4.69 lbs. of butter fat in her butter, or 2.862 lbs., while her milk for these days contained in all 3.813 lbs. of fat; 2.862 is 75.1-100 of 3.813, or the churnability of the milk fat was 75.1 per cent.:

Churnability of Milk Fat in Fer Cent.

Period I.	Sylvia.	Topsy.	Period II.	Sylvia.	Topsy.	Period III.	Sylvia.	Topsy.
Nov. 29–Dec. 2 ..	75.1	94.2	Dec. 20–23 ..	81.9	87.9	Jan. 17–20 ..	84.3	89.5
Dec. 2–5.....	80.2	89 4	Dec. 23–26 ..	72.2	90.0	Jan. 21–23...	82.6	86.9
Dec. 6–9	76.8	72.7	Dec. 27–30 ..	85.7	87.9	Jan. 24–27...	90.5	87.6
Dec. 9–12...	91.9	82.8	Dec. 31–Jan. 2	79.1	90.3	Jan. 28–30...	85.1	88.2
Dec. 13–16 ..	82.7	93.5	Jan. 3–6.....	81.1	82.0	Jan. 21–Feb. 3	82.0	86.7
Dec. 16–19..	87.3	97.6	Jan. 7–9....	86.5	88.8	Feb. 3–6	71.2	87.0
			Jan. 10–13...	81.1	89.7	Feb. 7–10 ...	85.8	90.2
			Jan. 14–16...	....	89.8	Feb. 11–12 ..	82.0	88.3

In order to get the influence of the feed on the churning qualities of the milk fat, we will consider only the last two weeks of each period; the averages of the figures for these weeks we have taken as representative figures for each period:

Average Churnability of Milk Fat.

		Sylvia.	Topsy.
I	Ensilage period	84.7	86.4
II	Fodder corn period	82.2	87.2
III	Ensilage period	81.2	88.5
	Average of I and III	83.0	87.5
	Difference	—.8	—.3

The difference as regards the churnability of the milk fat is very small, on an average, only a little more than half a per cent. In last year's experiment a larger percentage of the milk fat re-appeared in the butter on ensilage feed than on fodder corn feeding, a result that was substantiated by other experiments. The small difference in the experiment under discussion may be due to other conditions that entered in and worked against, what seems from the evidence on hand to be a general rule. This question will be considered hereafter in the discussion of the second feeding experiment conducted this last year, where fodder corn and ensilage were fed as exclusive feeds; the rations in the experiment now being discussed were partly made up of grain feed, bran and corn meal, so we are not, strictly speaking, considering the effect of dry ration versus succulent ration, on the churnability of the milk fat. It is worth while noticing the varying percentages of fat that were recovered during the experiment. The milk and cream were treated as uniformly as possible under the circumstances, throughout the experiment. Nevertheless, the percentages of fat reappearing in the butter, changed within a week, for the same cow, on the same feed, from 77 per cent. to 92 per cent., and from 89 per cent. to 73 per cent. The highest percentage recovered was 96.7 per cent., and the lowest 72.7 per cent., or a range within the same period of nearly 25 per cent. Such differences occurring where all possible precautions were taken, it would seem that too much attention cannot be paid to the proper ripening of cream and the churning at right temperatures. In our experiments last year we worked under great disadvantages in having only poor facilities for keeping constant temperatures for ripening the cream. The dairy house we then had was small and unevenly heated; the cream being kept in tin cans untill a mess was obtained, had to be placed in a room hot during the day time and cold during the night. Naturally, when the weather was very cold the differences in the temperature were greatest. How much this will effect the churnability of the fat we can not say with our present knowledge of the subject of churning, but doubtless it is of no small importance. Our facilities for this work having now been greatly improved by the building of a new dairy house at the Farm, it is hoped that in coming years we may obtain more light on the question of churning, so far only little studied and understood.

It took from 18.38 pounds to 14.55 pounds of milk to make one pound of butter, in case of Sylvia, and from 21.68 pounds to 18.97 pounds for one pound of butter, in case of Topsy. Considering the last two weeks of each period, we get the following averages for each period:

Pounds of Milk Required to Make One Pound of Butter.

	Sylvia.	Topsy.
	lbs.	*lbs.*
Period I	16.65	20.18
Period II	16.23	20.52
Period III	15.52	19.35
Average of I and III	16.09	19.77
Difference	+.14	+.75

On fodder corn feeding, .14 lbs. and .75 lbs. more milk was required for Sylvia and Topsy, respectively, to make one pound of butter, than was necessary during the ensilage periods, showing that the latter feed was more valuable for butter production in this case.

In regard to the time required for churning it is interesting to note that as a rule it took longer for the butter to come, in case of cream during the ensilage periods. The average time required for churning is given in the following table:

Average Time Required for Churning.

	Sylvia.	Topsy.
Period I	25 min.	44 min.
Period II	26 min.	29 min.
Period III	34 min.	44 min.
Average of I and III	30 min.	44 min.
Difference	—4 min.	—15min.

It took, on an average, four minutes longer to churn Sylvia's cream when she was fed the ensilage rations, than it took to churn her cream while on fodder corn, and 15 minutes longer for Topsy's cream under the same conditions. This is a general experience with us; we have always found that cream from cows on ensilage feed has required longer time for churning than has cream from dry fed cows.

COMPOSITION OF SAMPLES OF BUTTER FAT.

The quantities of volatile fatty acids present in the samples of butter fats from the last week of each period were determined by the Reichert method, modified by Wollny.*

The viscosity of the butter soaps in the same samples as with preceding determinations, was determined according to Babcock's method.†

The melting points of the samples of butter fats have been given before. The following table gives the results of the partial analysis of the samples:

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* Bulletin No. 13, Part IV., 460, U. S. Department of Agriculture, Div. of Chemistry.

† N. Y. Agr. Expt. Sta. (Geneva), Report of 1887, pp. 380-389.

Volatile Fatty Acids of Butter Fats and Viscosity of Soaps.

DATE OF CHURNING.	Feed.	SYLVIA.		TOPSY.	
		Volatile acids.	Viscosity.	Volatile acids.	Viscosity.
Dec. 18..........	Ensilage ration....	30.3 c c	92	30.5 c c	72
Dec. 21...........	Ensilage ration....	29.4	82	32.1	96
Jan. 15...........	Fodder corn ration.	27.6	76	30.3	96
Jan. 18...........	Fodder corn ration.	28.0	84	29.5	76
Feb. 13...........	Ensilage ration....	29.2	92	30.2	88
Feb. 15...........	Ensilage ration....	28.6	96	29.2	94

The average of these figures will be as follows:

Volatile Fatty Acids and Viscosity of Soaps.

PERIOD.	Feed.	SYLVIA.			TOPSY.		
		Volatile acids.	Viscosity.	Melting point.	Volatile acids.	Viscosity.	Melting point.
I.....	Ensilage...	29.85 c c	87	34.1°c	31.30 c c	84	34.3°c
II.....	Fodder corn	27.80	80	33.8	29.90	86	34.4
III.....	Ensilage...	28.90	94	35.2	29.70	91	35.6
Average of I and III.		29.38	90.5	34.7	30.50	88.5	35.0
Difference...........		–1.58 c c	–10.5	–.9	–.60 c c	–2.5	–.6

The feed seems to have influenced the butter fat as regards its composition in the following manner: There was a decrease in the amount of volatile fatty acids found by the Reichert-Wollny's method, a corresponding decrease in the viscosity of the soap solutions made from the fats, and a decrease in the melting point of the fats, on account of the feeding of fodder corn during the second period.

In a recent experiment by Dr. Mayer,* in Wageningen (Holland), in regard to the influence of certain feeds on the melting point and composition of the butter fat, ensilage was found to produce a harder melting butter than hay or pasture. Kirchner† obtained opposite results in comparing ensilage with beets; the melting point of the butter fat when the cows were fed beets was found 7° Centigrade higher than that of the butter fat from the ensilage period.

The above results as regards the influence of the ensilage on the volatile fatty acids in the butter fat do not coincide with those found by Mayer. In the above cited paper, Mayer calls attention to the fact that the quantity of volatile acids in the butter fat decreases with the advance of the lactation period; the same has been shown to be the case by Nilson‡ in his elaborate investigations concerning the milk fat, and is also affirmed by the above results. It would also seem from the above table that the melting point of the butter fat is raised with the advance of the lactation period, as might be inferred from the preceding conclusion.

THE KEEPING QUALITIES OF THE BUTTER PRODUCED.

By the courtesy of Mr. A. H. Barber, commission merchant, 183 South Water street, Chicago, Ill., we were enabled to have the butter produced on the experiment graded according to its flavor, grain and color. Of the butter churned during each week of the experiment, two pounds of the butter from the first churning was put in tight tin cans and at once forwarded to Chicago; the butter from the second churning was put in similar cans and kept at a uniform temperature in our store room for twenty days, and then forwarded to Chicago and graded. It was hoped in this way to get some data on the question of the keeping qualities of butter from dry feed and from ensilage. This, however, proved not to be the case. Practically no difference could be discovered in the markings; these also came very low on account of the deleterious influence of the conditions present during the experiment on the quality of the butter, so that the results cannot be directly applied to practical trials. The confinement of the cows during the weeks when excrements were collected, and the monotonous feed for a length of time cannot but influence the flavor of the butter produced in a serious manner.

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* Landwirtschaftliche Versuchs-Stationen XXXV., 261-282.

† Milchzeitung XVII., 125.

‡ Kongl. Landtbruks-Akademiens Handlingar, 1887, page 55.

THE SKIMMED MILK AND BUTTERMILK ON THE EXPERIMENT..

It is not intended to discuss in detail here, the data obtained in regard to the composition of the skimmed milk and the buttermilk during the different periods. We shall only consider the last two weeks, and give the average of these. In the skimmed milk, solids, fat, viscosity and specific gravity were determined; in the buttermilk, solids and fat.

Average Composition of Skimmed Milk and Buttermilk—in per cent.

	SYLVIA.						
	Skimmed Milk.					*Buttermilk.*	
	Solids.	Fat.	Solids not fat.	Viscosity.	Sp. Gr.	Solids.	Fat.
Period I..........	10.27	.40	9.87	216	1.0378	9.09	.42
Period II....	10.35	.25	10.10	219	1.0382	9.85	.62
Period III........	10.22	.21	10.01	219	1.0390	10.23	.90
Av. of I and III..	10.25	.31	9.94	218	1.0384	9.66	.66
Difference........	+.10	—.06	+.16	+1	—.0002	+.19	—.04
TOPSY.							
Period I..........	9.32	.30	9.02	193	1.0347	8.52	.35
Period II.........	9.28	.22	9.06	186	1.0344	9.10	.65
Period III........	9.44	.17	9.27	192	1.0357	9.67	.37
Av. of I and III..	9.38	.24	9.14	193	1.0352	8.80	.36
Difference........	—.10	—.02	—.08	—7	—.0008	+.30	+.29

Any connection between the feed given and the composition of the skimmed milk and the buttermilk, can hardly be traced in the above figures; the ensilage feed can certainly have no marked influence on the creaming process; the milk in both cases contained slightly more fat, on account of, or coincident with, the fodder corn feeding; the creaming, however, for both cows during the second period was as complete as could be expected on the deep setting system; ice was used, which insured nearly as complete creaming as would be obtained by use of the centrifuge.

MICROSCOPICAL WORK DONE.

The number of fat globules in the new milk and the skimmed milk was determined daily during the last week of each period, and also the size of the globules. Babcock's method of counting the globules was adopted.*

The method of proceeding is as follows: 10 cc. of new milk are diluted with distilled water to 500 cc., the milk is carefully mixed, and three pieces of capillary tubes, 2–3 centimeter long and about one-tenth of a millimeter inside diameter, are put into the milk; by capillary action the tubes are at once filled; the ends of the tubes are closed with a little vaseline, and the tubes mounted in glycerine. The inside diameter is measured by a small micrometer, and the globules contained in a length of fifty divisions on the scale counted after about half an hour. The value of one division of the micrometer used was .0024 millimeter. Six readings were taken from each tube.

.0024
50
.1200

To be able to compare the tubes with one another, the number of globules is calculated that would have been present in 50 divisions of a tube with a diameter of 100 divisions of the micrometer scale, using the formula $\frac{1000\,n}{d^2}$ where *n* is the number of fat globules found in 50 divisions and *d* the diameter of the tube. As the value of one of the divisions of the micrometer scale used (the same one as was used by Dr. Babcock in his original investigations) was

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*Fourth Annual Report N. Y. Agr'l Exp. Station, Geneva, 1885, p. 266–275.

0.0024 mm., the capacity of fifty divisions was 0.005425 cubic millimeters; as the milk was diluted fifty times its volume, the capacity of a tube, 100 divisions in diameter and 50 divisions in length, would be 0.0001085 cubic millimeters of milk; from the number of globules found in a tube of these dimensions, the number that would be present in 0.0001 cubic millimeter can be calculated by dividing by 1.085 or multiplying by .92. In case of skimmilk which was only diluted 10 times its volume, 50 cc. to 500 cc., we divide by 5.245.

In considering the results obtained, we shall take the new milk first; average figures are given:

Number of Fat Globules in New Milk.

		SYLVIA.			TOPSY.		
DATE.	Feed.	Diam. of tube 100 div.	No. of globules in .0001 cmm.	Relative size.	Diam. of tube 100 div.	No. of globules in .0001 cmm.	Relative size.
Dec. 13–18..	Ensilage.....	174	161	351	118	108	389
Jan. 10–15..	Fodder corn.	182	167	359	123	113	387
Feb. 7–12..	Ensilage.....	225	207	311	147	136	350
Average of ensilage periods............		200	184	331	133	122	370
Difference...........		−18	−17	+28	−10	−9	+17

We note here, first, that in case of both cows there is an increase in the number of fat globules in the milk with advancing lactation, and a decrease in the relative size of the globules; second, that the influence of the dry feed seems to have been to decrease the number and increase the relative size of the fat globules. The results in both cases are very marked.

That the first proposition holds good, is proved by the investigation conducted after the close of this experiment, as to the number and size of fat globules in the milk of the two cows experimented on. Up to date, the milk of Sylvia and Topsy has been analyzed, and the number of fat globules determined, three times, six days at a time, with an intermission of one or two months. The averages of each series of determinations are given in the accompanying table:

Average Number of Fat Globules in New Milk.

DATE.	Feed.	SYLVIA.					TOPSY.				
		Av. wt. of milking.	Fat in milk.	Diam 100 div.	In .0001 cmm.	Relative size.	Av. wt. of milking.	Fat in milk.	Diam 100 div.	In .0001 cmm.	Relative size.
		lbs.	*per ct.*				*lbs.*	*per ct.*			
Apr. 15-20	Dry Feed	11.5	6.13	213	197	313	22.1	4.38	201	185	241
May 23-28	Pasture..	18.3	5.39	247	227	239	28.0	4.00	218	200	203
July 22-27	Pasture..	11.8	5.25	298	275	193	14.6	4.82	343	318	152
Aug. 22-27	Pasture..	4.7	5.97	355	326	184	....	....	....	......	....

The fat globules in the milk from these two cows increased in number and decreased in relative size with the advancing lactation period. If we compare the number of globules and their size in the first set of determinations, December 13–18, with the last determinations for both cows, July 22–27, we notice that the number of fat globules at the latter period had increased 40 per cent. and 71 per cent. for Sylvia and Topsy, respectively, and their size had decreased 38 per cent. and 37 per cent. for Sylvia and Topsy, respectively. The feed April 15–20, was fodder corn, corn meal and bran; May 23–28, blue grass pasture and shorts; July 22–27, pasture (pretty dry, mostly marsh grass) and bran; and August 22–27, pasture (very dry) and bran. The cows were dried up, Topsy, August 9, and Sylvia, September 11, previous to calving. As will be seen from the introduction to this paper, the cows came in fresh, Sylvia, November 14, and Topsy, October 15, 1888.

Turning now our attention to the microscopical examination of the skimmed milk, we have the following averages of the determinations of the number and the size of the fat globules.

Number of Fat Globules in Skimmed Milk.

	SYLVIA.			TOPSY.		
	Diam. of tube 100 div.	No. of globules in .0001 cmm.	Relative size.	Diam. of tube 100 div.	No. of globules in .0001 cmm.	Relative size.
Period I.........	111	20	142	64	12	194
Period II........	75	14	169	49	9	169
Period III.......	87	16	84	77	14	118
Av. of I and III.	99	18	113	71	13	156
Difference.......	−24	−4	+56	−22	−4	+13

On account of the fodder corn feeding in the second period, or coincident with the same, we have a decrease in the number of fat globules in the skimmed milk, and an increase in their relative size; that is, the skimmed milk follows the new milk as regards the change of number and size of fat globules on succulent and dry feed.

DIGESTIBILITY OF RATIONS FED.

The digestibility of the rations fed in the different periods of the experiment was determined during the third week of each period (second week of period I); both the solid and fluid excrements were then collected, sampled, and subjected to chemical analysis. We shall here only give the results of the determinations for each cow. The cows ate all their feed during the ensilage periods; in the third week of the fodder corn period both left some fodder uneaten, which was sampled and analyzed. The following tables give the composition of the samples of dung collected, and of the samples of refuse feed:

Percentage Composition of Samples of Dung.

	SYLVIA.			TOPSY.		
	Period I. No. 661.	Period II. No. 663.	Period III. No. 665.	Period I. No. 662.	Period II. No. 664.	Period III. No. 666.
Moisture	85.90	84.22	85.56	86.72	85.33	86.65
Dry matter	14.10	15.78	14.44	13.28	14.67	13.25
Dry matter contained						
Ash	10.93	10.51	11.43	10.95	10.45	10.88
Ether extract	3.72	4.39	4.61	3.10	3.09	2.15
Crude fiber	26.91	23.44	25.96	26.42	23.90	28.41
Crude protein	12.14	11.77	10.13	12.40	12.19	9.98
Sugar	0.00	0.00	0.00	0.00	1.08	0.00
Starch, gums, etc.	46.30	49.89	47.87	47.13	49.29	48.58
	100.00	100.00	100.00	100.00	100.00	100.00
Alb. N	1.79	1.68	1.53	1.92	1.71	1.60
Amide N	.15	.20	.09	.06	.24	0.00
Pct. Amide N	7.72	11.91	5.55	3.03	12.31	....

Percentage Composition of Samples of Refuse Feed.

	SYLVIA.	TOPSY.
	Period II, third week.	Period II, third week.
Moisture	40.50	39.44
Dry matter	59.50	60.56
Dry matter contained —		
Ash	6.31	6.88
Ether extract	1.71	2.63
Crude fiber	36.78	34.34
Crude protein	5.56	6.19
Sugar	3.06	4.26
Starch, gums, etc	46.58	45.70
	100.00	100.00
Albuminoid N	.67	.74
Amide N	.22	.25
Pct. Amide N	24.72	25.25

The digestibility co-efficients of the rations fed (i. e., the percentages of the components of the rations assimilated by the animals) are given in the following table:

Digestibility of Rations Fed. in Per Cent.

Period.	Name of cow.	Dry matter.	Ash.	Ether extract	Crude fiber.	Crude protein	Sugar.	Starch, gums, etc.	Albuminoids.
				Ensilage Ration.					
I........	Sylvia........	64.1	29.0	67.4	47.4	64.7	100	70.5	55.8
I..	Topsy.........	63.1	27.2	72.5	51.0	58.6	100	68.6	47.8
III.......	Sylvia........	65.3	26.4	57.1	49.0	70.4	100	71.6	61.7
III.......	Topsy.........	65.4	25.6	79.6	50.3	66.2	100	70.7	55.4
Average digestibility of ensilage ration....... ...		*63*	*27*	*69*	*49*	*65*	*100*	*70*	*55*
				Fodder Corn Ration.					
II........	Sylvia.... ..	62.9	31.9	52 8	47.8	68.2	100	67.4	61.3
II.... ...	Topsy	61.0	29.2	60.6	50.8	64.0	92.2	65.2	56.0
Average digestibility of fodder corn ration. ...		*62*	*31*	*57*	*49*	*66*	*96*	*66*	*59*

As with last year's experiment, where similar feeding stuffs were fed, these results show no great difference in the nutritive value of the ensilage and fodder corn rations. There are in both cases somewhat higher digestibility co-efficiencts for the dry matter of the ensilage rations, and for the nitrogen-free extract. If we take the average of this and last year's results regarding the digestibility of the rations fed, these being made up of ensilage and corresponding dry fodder corn, and in addition, the same quantities of bran and of corn meal, we have the following data:

Digestibility of Ensilage and Fodder Corn Rations.

RATION.	No. of cows.	No. of trials.	Dry matter.	Ash.	Ether extract.	Crude fiber.	Crude protein.	Nitrogen-free extract.	Albuminoids.
			Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Corn ensilage, bran and corn meal..	3	6	64	23	71	53	67	71	56
Fodder corn, bran and corn meal..	3	6	60	16	63	50	69	66	58

The dry matter, crude fiber and nitrogen-free extract of the ensilage ration are shown to be somewhat more digestible than the same components in the fodder corn ration, while the crude protein and the albuminoids of the latter were slightly more digestible than those of the ensilage ration. The differences, however, are small.

SECOND EXPERIMENT, 1888-89. FODDER CORN vs. CORN ENSILAGE AS EXCLUSIVE FEEDS.

In this experiment the primary object was to ascertain the digestibility of fodder corn and of corn ensilage, of the same variety and maturity; to see whether the changes occurring in the silo affect the fodder for the better or the worse as regards its digestibility. At the same time, the opportunity was taken to observe the influence of the two feeds on the churnability of the milk fat. Previous experiments made at this Station and elsewhere, tend to show that the nature of the food in some way influences the churning qualities of the cream, so that where a part of, or the whole ration is made up of a succulent feed or feeds, milk of the same richness in fat will yield more of the fat in the butter than will be obtained in case of milk from dry fed cows. Attention to this fact was called by the writer in the discussion of last year's experiment, where, with a decrease in the milk flow there was an increase in the quantity of butter produced during the ensilage period, over that produced during the fodder corn periods.* In both last and this year's experiment, part of the rations in the ensilage period was made up of grain feed, that might therefore exert an influence of its own on the churnability of the fat, and thus conceal the effects of the succulent feed. In the experiment to be described the rations were, dry fodder corn and corn ensilage, fed exclusively, and more definite results of the effects of the succulent feed upon the churning quality of the fat was therefore looked for.

GENERAL PLAN OF THE EXPERIMENT.

Owing to the trying character of the rations to be fed, only very short periods were planned, viz., two weeks each. During the first period dry fodder corn was fed; during the second period corn ensilage, and during the third, again dry fodder corn.

The excrements were collected during the latter week of the first two periods. The third period was added in order to eliminate the influence of the advance of lactation period on the milk and butter production.

ANIMALS USED ON THE EXPERIMENT.

The following data give the necessary information concerning the cows used on the experiment:

Name of cow.	Breed.	Age.	Time of last calving.	Initial weight.	Notes.
Bessie	Grade Jersey.....	9 years....	Nov. 24, 1888..	858 lbs..	Served Dec. 12, 1888.
Bunn	Cross bred Holstein and Jersey.	5½ years..	Nov. 18, 1888..	975 lbs..	Served Dec. 9, 1888.

FEEDING STUFFS USED.

The fodder corn used was the Sibley's Sheep Tooth variety. Similar fodder was put into the stone silo at the university farm and shocked in the field. On October 9th the shocked fodder was transferred to the barn and stored there. Several varieties were put into the stone silo between layers of straw, so no figures were secured as regards the loss during the siloing process. The dry fodder corn was cut and fed unhusked; in filling into the silo the corn was also cut directly, without removing the ears. The ensilage was of superior quality, as was also the fodder corn. In all, about fifty tons were filled into the silo; length of siloing period, five months. The bran used in the third period in case of Bessie was made by the roller process.

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*Fifth Annual Report Wis. Agr. Experiment Station, 1888, pp. 28-63.

COMPOSITION OF FEEDING STUFFS.

The following table gives the chemical composition of the above mentioned feeding stuffs:

Percentage Composition of Feeding Stuffs.

	No. 652. Ensilage. Period II.	No. 648. Fodder corn Period I.
Moisture	62.37	38.58
Dry matter	37.63	61.42
Dry matter contained—		
Ash	4.09	4.39
Ether extract	3.25	2.25
Crude fibre	20.83	27.73
Crude protein	7.41	7.03
Sugar	3.96	1.42
Starch, gums, etc	60.46	57.18
	100.00	100.00
Albuminoid N	.72	.83
Amide N	.47	.30
Per cent. Amide N	39.68	26.67

The ensilage contained .80 per cent. lactic acid, and .14 per cent. acetic (volatile) acid.

METHOD OF CONDUCTING THE EXPERIMENT.

The experiment was conducted in a similar way as the preceding ones of this kind. The milk from the evening's and morning's milking was sampled and analyzed daily for solids and fat; the viscosity and the specific gravity of every sample analyzed were also determined. The milk was set in small Cooley cans, each milking by itself, and the milk from each cow by itself. The skimmilk was drawn off after twelve hours, and the cream put aside in tin cans where the produce from three and four days, alternately, was united, ripened and churned. A small sample of skimmilk from each skimming was put aside in a quart glass jar, and the milk from three and four days, alternately, sampled and analyzed. A careful record was kept of the data connected with the churning, the temperature, time of churning, etc. Both new milk and skimmed milk were subjected to microscopical examination during the last week of each period. The butter milk was sampled and analyzed every churning, and its acidity determined.

The experiment began February 14, 1889, and lasted until March 27.

RATIONS FED.

The cows were fed fodder corn *ad libitum* during the first and the third period, and corn ensilage, likewise *ad libitum*, during the second period. The farm hand attending to the cows watched them closely and gave them feed according to their appetites. As a rule, however, they did not eat as much as was expected, and a little of the coarser part of the feed was often left uneaten; the feed boxes were cleaned every afternoon, and the refuse fodder weighed back daily and sampled after each week.

In addition to the fodder the cows received about twenty grams (⅔ of an ounce) of salt per day, given half in each feed.

The following table gives the quantities of food consumed by the two cows on the experiment, and also the dry matter, and the digestible matter in the food; the latter was determined directly during the collection weeks, and during the other weeks calculated from the digestibility co-efficients thus found.

Dry Matter Eaten per Day in Pounds.

	Amount eaten.	Fodder corn.	Ensilage.	Bran.	Total.	Total digestible matter.
BESSIE.						
Period I, week 1	20.93	12.23	....	....	12.23	7.23
Period I, week 2	20.00	11.74	....	....	11.74	7.17
Period II, week 1	46.19	......	14.89	....	14.89	9.19
Period II, week 2	39.61	....	15.48	....	15.48	9.85
Period III, week 1	20.01	9.75	....	6.47	16.22	9.88
BUNN.						
Period I, week 1	31.14	18.34	....	....	18.34	10.73
Period I, week 2	26.17	15.72	....	....	15.72	9.11
Period II, week 1	64.25	....	20.71	....	20.71	13.08
Period II, week 2	54.29	....	20.51	....	20.51	12.93
Period III, week 1	25.23	18.98	....	....	18.98	11.16
Period III, week 2	22.00	18.08	....	....	18.08	10.63

GENERAL CONDITION OF THE COWS.

A digestion experiment is always more or less hard on the animals experimented on, and this is so much the more the case where, as in this instance, only one kind of food was fed. The cows naturally tire of the feed and easily lose their appetites; especially cows of marked nervous constitutions, as Bessie, on this experiment. As would therefore naturally be expected, the live weights of the cows fell considerably, and the yield of milk decreased more rapidly than would have been the case, had the cows been supplied with a combination of foods more suited to their tastes; the same is true in regard to the quality of the milk given. At the end of the second period both cows looked very thin and poor, Bessie especially so; as Bessie, on coming back on fodder corn in third period, did not show any signs of relishing the feed, 10 lbs. of bran were added to her ration March 15. Bunn received nothing but fodder corn. March 18 the experiment was discontinued as regards Bessie; with Bunn it was continued for a week longer, as planned. Bunn seemed to keep up a fair appetite through the whole experiment, and did not in any way suffer from the monotonous feed, as did Bessie.

The cows were let out daily during the experiment, except during collection weeks, when they were kept in the stable all the time.

DIGESTIBILITY OF FODDER CORN AND CORN ENSILAGE.

We shall now give the results of the determinations of the digestibility of the two feeding stuffs under consideration. The excrements from the two cows were collected during the second weeks of the two first periods.

The following table gives the composition of the samples of dung collected, and the fodder residues:

Percentage Composition of Samples of Dung.

	FODDER CORN PERIOD.		ENSILAGE PERIOD.	
	Bessie. No. 667.	Bunn. No. 668.	Bessie. No. 669.	Bunn. No. 670.
Moisture	86.32	87.19	86.08	87.05
Dry matter	13.68	12.81	13.92	12.95
Dry matter contained —				
Ash	9.32	9.29	9.16	9.53
Ether extract	1.76	1.75	1.63	1.58
Crude fiber	28.63	30.11	28.68	30.10
Crude protein	9.43	9.25	10.63	10.00
Sugar	0.00	trace	0.00	0.00
Starch, gums, etc	50.86	49.60	49.90	48.79
	100.00	100.00	100.00	100 00
Albuminoid N	1.45	1.42	1.56	1.42
Amide N	.06	.06	.14	.18
Per cent. Amide N	3.80	4.05	8.24	11.26

Composition of Fodder Residues.

	WASTE FODDER CORN		WASTE ENSILAGE.	
	Bessie. No. 650.	Bunn. No. 651.	Bessie. No. 653.	Bunn. No. 654.
Moisture	52.54	50.95	78.64	74.40
Dry matter	47.46	49.05	21.36	25.00
Dry matter contained—				
Ash	4.01	3.92	5.19	5.20
Ether extract	2.02	2.22	1.60	1.31
Crude fiber	36.33	37.26	27.12	32.48
Crude protein	3.45	2.94	6.31	6.00
Sugar	4.32	3.96	2.40	3.08
Starch, gums, etc	49.87	49.70	57.38	51.93
	100.00	100.00	100.00	100.00
Albuminoid N	.30	.38	.66	.60
Amide N	.24	.09	.35	.36
Per cent. Amide N	43.48	19.14	34.65	39.26

Below are given the results of the determinations of the digestion co-efficients:

Digestion Co-efficients for Fodder Corn and Corn Ensilage.

	Dry matter.	Ash.	Ether extract	Crude fiber.	Crude protein	Sugar.	Starch.	Albu-min-oids.	Amides
a, Fodder Corn.									
BESSIE.									
Fed 20.00 lbs. fodder corn.	12 32	.58	.28	3.41	.86	.17	7.02	.63	.23
1.13 lbs. refuse feed....	.54	.02	.01	.20	.02	.02	.27	.01	.01
Eaten..	11.78	.56	.27	3.21	.84	.15	6.75	.62	.22
33.71 lbs. dung....	4.61	.43	.08	1.32	.41	....	2.35	.41	....
Digested..........	7.17	.13	.19	1.89	.43	.15	4.40	.21	.22
Pct. digested......	60.9	23.2	70.4	58.9	51.2	100.0	65.2	33.9	....
BUNN.									
Fed 26.17 lbs. fodder corn.........	16.11	.75	.37	4.46	1.13	.23	9.17	.83	.30
.54 lbs. refuse feed	.26	.01	.01	.10	.01	.01	.12	.01	....
Eaten............	15.85	.74	.36	4.36	1.12	.22	9.05	.82	.30
52.61 lbs. dung.... .	6.74	.63	.12	2.03	.60	....	3.34	.60	....
Digested......	9.11	.11	.24	2.33	.52	.22	5.71	.22	.30
Pct. digested.... .	58.8	14.9	66.7	53.4	46.4	100.0	63.1	26.8	....
b, Corn Ensilage.									
BESSIE.									
Fed 43.07 lbs. ensilage............	16.25	.70	.53	3.38	1.20	.64	9.80	.78	.47
3.36 lbs. refuse feed	.72	.04	.01	.19	.05	.02	.41	.08	.02
Eaten.............	15.53	.66	.52	3.19	1.15	.62	9.39	.70	.45
40.82 lbs. dung.....	5.68	.52	.09	1.63	.55	....	2.84	.55	....
Digested..........	9.85	.14	.43	1.56	.60	.62	6.55	.15	.45
Pct. digested......	63.4	21.2	82.7	48.9	52.2	100.0	69.7	21.4	....
BUNN.									
Fed 55.00 lbs. ensilage	20.73	.89	.67	4.31	1.53	.82	12.51	.93	.60
.71 lbs. refuse feed	.18	.01	.00	.06	.01	.01	.09	.01	.00
Eaten..	20.55	.88	.67	4.25	1.52	.81	12.42	.92	.60
58.80 lbs. dung... .	7.62	.72	.12	2.29	.68	.. ....	3.73	.68	....
Digested..........	12.93	.16	.55	1.96	.84	.81	8.69	.24	.60
Pct. digested......	62.9	18.2	82.1	45.4	55.3	100.0	70.0	26.1	....

It will be seen that the sugar in both feeding stuffs was all digested, as would be naturally supposed. Figuring the sugar in with the starch and gums, we get the following digestibility co-efficients for the nitrogen-free extract:

Co-efficients for Nitrogen-free Extract.

a, Fodder corn	for Bessie	66.0 per cent.
	for Bunn	64.0 per cent.
b, Corn ensilage	for Bessie	71.6 per cent.
	for Bunn	71.8 per cent.

The samples of dung contained small quantities of amide nitrogen; the above table has been prepared, however, on the supposition that all amides are digestible, as is generally admitted. Their appearing in the excrements this year, as well as last year, shows that, under certain circumstances at least, they are always present in the dung in small quantities; they may be formed in the bodies of the animals, as decomposition products of the albuminoids.

Summary of Digestibility Co-efficients for Fodder Corn and Ensilage.

PERIOD.	Name of Cow.	Dry matter.	Ash.	Ether extract.	Crude fiber.	Crude protein.	Nitrogen-free extract.	Albuminoids.
	a, Fodder Corn.							
I	Bessie	60.9	23.2	70.4	58.9	51.2	66.0	33.9
I	Bunn	58.8	14.9	66.7	53.4	46.4	64.0	26.8
	Average	***60***	***19***	***69***	***56***	***49***	***65***	***30***
	b, Corn Ensilage.							
II	Bessie	63.4	21.2	82.7	48.9	52.2	71.6	21.4
II	Bunn	62.9	18.2	82.1	45.4	55.3	71.8	26.1
	Average	***63***	***20***	***82***	***47***	***54***	***72***	***24***

A comparison of the digestibility co-efficients for the fodder corn and corn ensilage will show the latter to be fully equal, and even somewhat superior to the former; 63 per cent. of the dry matter of the corn ensilage were digested, as an average of the trials with two cows, against 60 per cent of the dry matter of the dried fodder corn. The protein bodies and the nitrogen-free extract (sugar, starch, gums, etc.), were more digestible, while crude fiber was less digestible in case of corn ensilage than in case of fodder corn.

This is the first digestion experiment, to the writer's knowledge, of ensilage made from Indian corn as exclusive feed; the results obtained, therefore, cannot be compared with work done elsewhere. In case of fodder corn, digestion experiments have been conducted by Dr. Moser and Dr. Armsby.*

The fodder used in this experiment was what is properly called fodder corn, i. e., Indian corn allowed to develop ears and to mature, where the whole plant, stalk and ears, was cured in the field and used for feeding purposes. Armsby's experiment was with stover, i. e., with corn fodder, grown mainly for the sake of the ears, from which the ears are consequently removed and only the stalks cut for cattle feed. Moser's experiments were conducted with one sheep; Armsby's with two steers. The results of the experiments are given in the following table:

Digestian Co-efficients for Indian Corn.

Fodder.	Dry matter.	Ash.	Ether extract.	Crude fiber.	Crude protein.	Nitrogen-free extract.
Green fodder corn — Moser...	....	....	75	72	73	67
Cured corn stover — Armsby..	62	45	52	66	52	64
Cured fodder corn — the writer	60	19	69	56	49	65

The last two experiments given in the above table are the only ones that can be strictly compared. It will be seen that the results for the main components of fodder agree very well; the crude fiber is found somewhat less digestible in the writer's experiment, but as for dry matter, crude protein, and nitrogen-free extract, the agreement is as good as could be expected. The co-efficients obtained show the fodder corn to be more digestible than most of our other common coarse fodders; the digestibility co-efficients for these have been found to vary for dry matter, for instance, between 50 and 60; for crude protein, between 41 and 57; for nitrogen-free extract, between 39 and 65, and so on.*

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* See Bulletin No. 3, Agr'l Exp. Station, State College, Pa., April, 1888.

CHURNABILITY OF MILK FAT.

The records of the composition of the milk given by the two cows have been published in an article by the writer, entitled, "Short's Method for Laboratory Purposes," in *Agricultural Science*, 1889, pp. 131–132. To make the description of the experiment complete, it will here only be necessary to give the average quantities of milk and butter produced. As will be remembered from the introductory remarks, the cow Bessie was fed bran in addition to fodder corn during the third period of the experiment, so the first and third periods with her are not directly comparable; this, on the other hand, is the case withBunn.

Average Daily Yield of Milk and Butter, in Pounds.

PERIOD.	Week.	BESSIE.		BUNN.	
		Milk.	Butter.	Milk.	Butter.
I	1	15.17	.643	21.59	.696
	2	13.38	.552	18.47	.480
II	1	12.81	.469	18.33	.493
	2	12.77	.456	18.09	.474
III	1	12.62	.474	17.24	.437
	2	....	....	16.13	.410

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* Armsby, loc. cit., p. 10.

Composition of Butter — Churnability of Milk Fat.

Period.	Week	Bessie.					Bunn.				
		Water.	Fat.	Casein.	Melting point of fat.	Ch'rn'd out.	Water.	Fat.	Casein.	Melting point of fat.	Chr'n'd out.
		Per ct.	*Pr ct.*	*Per ct.*	° C.	*Per ct. fat*	*Per ct.*	*Pr ct.*	*Per ct.*	° C.	*Per ct. fat.*
I...	1	18.52	80.14	1.34	32.9	75.0	19.48	79.15	1.37	32.7	78.7
	2	16,20	82.27	1.53	32.6	81.7	18.46	80.41	1.13	33.4	73.1
II..	1	17.70	81.22	1.08	34.6	76.2	18.80	80.04	1.16	34.4	73.3
	2	19.09	77.86	1.05	34.5	73.8	20.45	78.96	1.09	34.9	75.1
III.	1	22.37	70.65	.98	34.6	75.7	20.22	78.55	1.23	32.6	69.6
	2	....	. ....	....	.. ....	......	20.70	78.23	1.07	32.5	69.0

If we consider the second week of each period as a representative one, where the influence of the feed will have made itself felt, we have the following table:

Average Churnability of Milk Fat in Per cent.

FEED.	BESSIE.	BUNN.
Fodder Corn...	81.7	73.1
Corn Ensilage...	73.8	75.1
Fodder Corn*...	75.7	69.0
Av. of Fodder Corn Periods...		71.1
Difference...		+4.0

*Fodder corn and bran for Bessie (first week).

In the ensilage period four per cent. more of the milk fat was recovered in the butter than was obtained in the two fodder corn periods. With Bessie where bran was fed during the third period there was an increased churnability in this period; as the period only lasted one week, however, there cannot be placed much confidence in this result. The same conditions in our dairy house prevailed in this experiment, as were described in the preceding one; the influence of the feeding of a single food on the general condition of the cows may also have worked one way or another. The results do not show a very pronounced improvement; there seems, however, to be a tendency to an improvement of the churning qualities of the milk where ensilage was fed; a more definite conclusion, the facts on hand will hardly warrant.

With Bunn it took nearly a pound more milk to make a pound of butter on the ensilage feed than on the fodder corn feed. The composition of the skimmed milk was practically the same, while the buttermilk contained less fat during the ensilage period than the average of the two fodder corn periods. While these results are indicated in the experiment, it is not thought of sufficient importance to give them in fuller particulars; the experiment was primarily a digestion experiment, and the character of it was not such as would give indisputable results as regards the influence of the feed on the milk and butter product.

COMPOSITION OF SAMPLES OF BUTTER FAT.

As in the preceding experiment the samples of butter fat produced during the last week of each period were examined for volatile fatty acids, viscosity of soaps and melting point. The methods used were the same as previously described (p. 95). The following table gives the results:

Analysis of Butter Fats.

Date of churning.	Feed.	BESSIE.			BUNN.		
		Volatile acids.	Viscosity.	Melting point.	Volatile acids.	Viscosity.	Melting point.
Feb. 27.	Fodder corn	27.5 c c	92	32.4°C	28.8 c c	88	32.3°C
Mar. 1..	Fodder corn	26.6	94	32.7	30.0	84	32.5
Mar. 12.	Ensilage ...	28.9	72	34.4	30.0	76	35.5
Mar. 16.	Ensilage ...	27.3	88	34.6	28.1	84	34.3
Mar. 19.	*Fodder corn	26.0	84	33.7	27.1	82	32.9
Mar. 21.	*Fodder corn	29.4	76	35.2	29.6	92	32.3
Mar. 26.	Fodder corn	....	....	....	27.7	92	32.5
Mar. 30.	Fodder corn	....	....	....	29.6	92	32.4

* Fodder corn and bran for Bessie.

In order to trace the influence of the feed on the composition of the butter fat, we calculate the average figures for the different periods, considering only the last week of each period.

Average Composition of Butter Fats.

PERIOD.	Feed.	BESSIE.			BUNN.		
		Volatile acids.	Viscosity.	Melting point.	Volatile acids.	Viscosity.	Melting point.
I.......	Fodder corn	27.05 c c	93	32.55°C	29.40 c c	86	32.4°C
II......	Ensilage...	28.30	80	34.50	29.05	80	34.90
III.....	Fodder corn	27.70	80	34.45	28.65	92	32.45
Average of I and III		....	....	....	29.03	89	32.4
Difference........		....	....	....	....	—9	+2.5°c

While the amount of volatile acids in the samples of butter fat from Bunn was thus practically the same in this experiment during the ensilage period as average of the fodder corn periods, the viscosity of the butter fat soaps decreased, and the melting points of the fats were raised on the ensilage feed. The result as regards the latter determination agrees fully with those found on the preceding experiment, and also with what is clearly told in the data for the samples of butter fat from Bessie.

MICROSCOPICAL WORK.

The microscopical work done on this experiment is probably worthy of a more detailed description. In the introductory remarks to this experiment, account is given of the planning of the work. The following table gives the results. For explanation of the terms used I would refer to the part of this year's first experiment where the microscopical work is spoken of (p. 99). Bessie's milk was examined microscopically only during the two first periods.

Number and Size of Fat Globules.

PERIOD.	FEED.	BESSIE.			BUNN.		
		Diam. 100 div.	In .0001 cmm.	Relative size.	Diam. 100 div.	In .0001 cmm.	Relative size.
	a, New Milk.						
I.......	Fodder corn............	294	271	175	245	226	141
II......	Ensilage................	248	229	182	238	218	137
III....	Fodder corn............	......	......	......	198	182	178
	Av. of I and III.....	......	......	......	222	204	160
	Difference..........	......	......	......	+16	+14	—23
	b, Skimmed Milk.						
I.......	Fodder corn............	208	38	72	441	81	48
II......	Ensilage..............	111	21	148	242	44	116
III.....	Fodder corn............	......	......	......	241	45	72
	Av. of I and III....	......	......	......	341	63	60
	Difference........ ..	......	......	......	—99	—19	+56

The results, as far as the fat globules in the new milk go, are in perfect harmony with those obtained in the preceding experiment; the feeding of corn ensilage during the second period influenced the milk secretion in such a way, that the milk contained a larger number of fat globules, and these were of a smaller size than the average of the data for the two fodder corn periods.

As in the preceding experiment, this part of the investigation was continued after the close of the experiment, to study the effect of the period of lactation on the microscopical appearance of the milk. The milk from both cows was examined May 25–30, and July 22–27, in six day periods; the cows being dried up in the beginning of August prevented further study.

Number and Size of Fat Globules in New Milk.

DATE.	FEED.	BESSIE.					BUNN.				
		Av. wt. of milking.	Fat in milk.	Diam 100 div.	In .0001 cmm.	Relative size.	Av. wt. of milking.	Fat in milk.	Diam 100 div.	In .0001 cmm.	Relative size.
		lbs.	*per ct.*				*lbs.*	*per ct.*			
May 25-30	Pasture..	19.1	5.08	308	283	180	23.9	3.19	284	261	123
July 22-27	Pasture very dry.	5.2	6.35	381	350	186	8.8	3.68	345	317	116

Also in case of the milk from these two cows we observe an increase of the number of the fat globules in the milk with the advance of the lactation period. The size of the fat globules is practically the same in case of Bessie, while with Bunn the size goes down with the advancing lactation period, as was found in the preceding experiment; with both cows, however, it is to be remembered that their milk was only examined during a comparatively short part of their lactation period; the first determination being made when they had been in milk eighty-eight and ninety-five days, with Bessie and Bunn, respectively. The size of the fat globules, as is well known, is an important factor in the creaming of the milk. It seems clear to the writer that the phenomena with strippers' milk, the difficulty of its creaming and churning, is perfectly explainable by the minuteness of the fat globules in such milk; the globules rise with much difficulty and, once risen, it is hard to make them adhere together in the churning. The phenomenon of the smaller yield of butter during the spring months from the same quantity of milk, reported by hundreds of observers, may be explained by the influence of the succulent feed on the size of the fat globules; it tends to reduce their size and consequently reduces the butter production in some measure. Other things being equal, milk with large fat globules will produce more butter than milk with small globules. The percentage composition of the milk does not tell anything as regards this point; milks with the same percentage of fat will have different values for butter production, if the fat globules of one milk are larger than those of another.

The influence of succulent feed on the size of the fat globules spoken of, would act in the direction of decreased butter production; the tendency of such feed to increase butter production, which has been found in experiments made at this Station as well as elsewhere, must therefore overcome this effect before it can make itself felt. As to how this is overcome, the knowledge on hand is not sufficient to explain; we must look for further experiments in this direction to throw new light on the question.

CONCLUSIONS.

The main results obtained in the digestion experiments conducted at this Station last year, and discussed in the preceding pages, may be briefly stated as follows:

1. The digestibility of corn ensilage is somewhat higher than that of dry fodder corn of the same variety and maturity. The same holds good with the rations tried, where bran and corn meal were fed in connection with the ensilage or fodder corn.

2. The digestible matter of corn ensilage and fodder corn have practically an equal value for milk production.

3. The churnability of the milk fat was improved on the second experiment on exclusive ensilage feed; on the first experiment no definite results were arrived at.

4. The fat globules of cows' milk increase in number and decrease in size as the period of lactation advances. Dry feed decreases the number and increases the size of the fat globules.

EXPERIMENTS WITH FODDER CORN AND ENSILAGE.

F. G. SHORT.

The work on the silo at this Station has been for the most part a series of endeavors to find the best and most economical method of handling, storing and preserving corn ensilage. That these endeavors have been in some degree successful, is shown by the steady improvement in the quality of the ensilage made, and a decrease in the loss of dry matter by mould and putrefactive changes. Although there is still a loss of about 15 per cent. of dry matter in the silo, this seems not so much greater than that undergone by fodder corn during the process of curing, as to prevent making a comparison of the relative economy of the two methods of preserving fodder. The work of the past year has been under the following heads:

a. Yield and composition of different silo corns.

b. A comparison of the economy of curing and siloing the same variety of corn.

c. Ensilage vs. fodder corn for milk production.

d. Losses in corn-stalks due to weathering.

e. Composition of different parts of the corn plant.

YIELD AND COMPOSITION OF DIFFERENT SILO CORNS.

VARIETIES OF CORN FOR ENSILAGE.

The question as to which is the best variety of corn for the silo is an important one at the present time. The exceptional weather for the past three summers has permitted the maturity of varieties of corn which in general do not ripen so far north as Wisconsin. The southern corns, characterized by an immense yield of fodder per acre, have played an important part in supplying forage during the repeated severe drouths of the past few years, and have given fine crops of fodder under conditions where, in many cases dent and flint corns have been partial failures. In view of the fact that the large varieties will usually not ripen in Wisconsin, it seems advisable to endeavor to find a corn which will combine a fairly large yield with early ripening. For the purpose of obtaining information on this subject there were planted at the Station nine varieties of corn, comprising flint, dent, sweet and the so-called ensilage corns. The varieties were as follows: King Philip (flint); Smedley Dent; Evergreen Sweet; Normandy White Giant; B. & W.; Sibley's Sheep Tooth; Southern Ensilage; Southern Horse Tooth; Fargo Bros. Ensilage. The last four varieties were southern corns. The Normandy White Giant was from seed received from the Department of Agriculture at Washington.

These corns are well-known typical varieties of their classes. The corns were planted in plots, May 24, 1888, on well prepared rich land. Setempter 6, samples were taken by cutting the corn from an area of 120 square feet, and from this large sample sub-samples were taken for analysis.

The result of the analyses will be found in the following table:

Table sohwing the weight of green fodder, dry matter, sugar and protein per acre.

	Date.	Wt. Green Corn per Acre.	Total Dry Matter.	Total Sugar.	Total Protein.
		lbs.	*lbs.*	*lbs.*	*lbs.*
King Philip (flint)....	Sept. 5	26200	8352	982.4	572.0
Smedley (large yellow dent)....	Sept. 5	33570	10160	1393.0	632.3
Evergreen Sweet................	Sept. 5	22690	5526	858.6	352.0
B. & W........................	Sept. 5	39800	9028	1329.0	474.5
Sibley's Sheep Tooth...	Sept. 5	31490	7785	1182.0	437.1
Southern Ensilage...............	Sept. 5	43700	11060	1877.0	697.7
Normandy White Giant........	Sept. 5	37390	9906	1237.0	625.0
Southern Horse Tooth..........	Sept. 5	42060	14070	2419.0	984.7
Fargo Bros' Ensilage...........	Sept. 5	38890	10150	1310.0	634.3

It is seen from the table that at the date of cutting, September 5, the value of the corns according to the yield of dry matter would be in the following order, beginning with the highest:

1. Southern Horse Tooth.
2. Southern Ensilage.
3. Smedley Dent.
4. Normandy White Giant.
5. Fargo Bros. Ensilage.
6. B. &. W. Ensilage.
7. Sibley's Sheep Tooth.
8. King Philip.
9. Evergreen Sweet.

Although the Southern Ensilage is slightly ahead of the Smedley Dent in actual pounds of dry matter produced, yet the greater maturity of the Smedley would probably place it second in the list, if ranked according to feeding value. While the above figures would indicate that the sweet and flint corns were of rather low value for the silo, yet we must take into account the fact that the summer of 1888 was exceptionally favorable to the growth of the southern and adverse to northern varieties. Another season may reverse these figures, especially if it is a cold rainy one. It is evident from the table that marked differences in composition, as well as yield, exist between the northern and southern corns. Also that the weight of green fodder per acre is no indication of the true value of the corn. The large, rank-growing corns, B. & W. and Fargo Bros. Ensilage, while giving in one case 5,000 and in the other 6,000 pounds more green fodder to the acre, yet gave no more nutritive matter than the Smedley, a yellow dent variety of the Pride of the North type, suitable for northern Illinois, but a little too large and late for a general field crop in this vicinity. We must, therefore, in judging of the value of a corn take into account the time necessary for its maturity. It is necessary that the corn be far advanced toward ripening and that it be sufficiently matured to have obtained its maximum growth without having lost its succulence; this condition is obtained when the kernel of the ear is glazed so as not to be easily dented with the nail. Besides having a greater feeding value, corn that has been allowed to mature to the point of glazing has nearly twice as much nutritive matter to the ton as that cut when the ears are just beginning to show the tassel.

METHODS OF PLANTING VARIETIES.

Formerly farmers thought that for fodder purposes corn should be sown broadcast; experience soon taught them that it was better to plant it in drills where it could get more sunlight and be less crowded. With the first silos came quite thick planting in the row, as much as a bushel of seed per acre being used. Such thick planting gave no ears and but watery stalks. Now the tendency is toward planting so thin that a fair crop of grain can be secured. For the large varieties of corn, with the rows four feet apart, the kernels should be dropped singly about every eight inches in the row. With smaller varieties the rows can be three and one-half feet apart with the grains six inches apart. A corn field is easier kept clean and the corn fodder easier gathered, when cut by hand if the stalks grow in hills. Flint corn planted three grains to the hill, with the hills two feet apart, in rows three and one-half feet apart, will give a large crop of fodder and grain.

At this Station several years since, we obtained 33,000 pounds of fodder per acre from flint corn planted two grains to the hill, with the hills two feet apart each way. The corn was easily cultivated and soon shaded the ground so that cultivation was no longer necessary. Nearly every stalk carried a good sized ear.

From what has been said it is very evident that the Station is in favor of smaller varieties of corn than has usually been planted for ensilage purposes. After urging that no variety be used that will not mature in ample time to be gathered into the silo before there is danger of frost, another precaution is that the corn be planted so thin that considerable grain will mature. The ordinary varieties of field corn, either dent or flint, will prove satisfactory for ensilage.

TIME OF CUTTING.

Repeated experiments have shown that to obtain the maximum amount of nutritive matter the corn must be allowed to reach a certain degree of maturity. The proper condition is apparently obtained when the corn has just passed the glazing stage, in the flint, and is well dented, in the dent corns. Experience and analysis indicate that corn cut at this stage is in the best possible condition for the silo.

COMPARISON OF SILOING AND SHOCKING FODDER CORN.

The preservation of green fodder by siloing is always accompanied by a certain degree of heat and fermentation of the mass. This fermentation and heating goes on at the expense of the nutritive matter of the fodder corn, the amount destroyed depending upon the length of time during which fermentation is allowed to proceed, and the degree of heat attained in the silo. The great objection to the silo has been that this loss of nutritive matter was much larger than by other methods of curing fodder. This was certainly so in some of the earlier silos, losses of 50 per cent. having been reported. Improvements in building and filling the silo have reduced this loss, but experiments still show a loss of from 10 to 25 per cent. This is certainly too large a loss to be ignored, but if other methods of saving fodder corn are accompanied by equal losses, the advantages possessed by the silo will overbalance the loss of nutritive matter, which improved methods may further largely reduce.

The experiments here reported are a continuation of those given in the Fifth Annual Report of this Station, and were conducted in nearly the same manner. Four silos, each with a capacity of about 10 tons, were filled with well matured corn of different varieties, each silo being filled as rapidly as possible, left for a day or two to settle, then filled to the top with fresh fodder corn. A layer of tarred paper was then put on, and the whole covered with a foot of sawdust. During filling, samples of fodder were taken for analysis. Every other load of fodder was carried back to the field and carefully shocked.

It was the intention to leave a part of the fodder corn in this experiment, shocked in the field and exposed to the snow and rain, till it was wanted for feeding, with the view of finding the effect of snow and rain on the fodder. In this we were disappointed, as but very little snow or rain fell till after the fodder was wanted for feeding trials. The fodder corresponding to silos No. 3 and 5, was left in the field for one month, and then stored in the loft of the barn; that corresponding to silos No. 1 and 2, was left out in the field till used on the experiments.

The weight of the fodder put into the silo, as well as the amount shocked, was carefully taken. The following table gives the amount of dry matter in the siloed and shocked corn:

Table Showing Losses in Siloing and Shocking Foddet Corn.

Silo No. 1.— Yellow Flint Corn.

	SILOED FODDER.				SHOCKED FODDER.			
	Put in silo.	Taken. out.	Loss.	Per cent.	Fresh.	Cured.	Loss.	Per cent. Loss.
	Lbs.	*Lbs.*	*Lbs.*	*Loss.*	*Lbs.*	*Lbs.*	*Lbs.*	
Weight of fodder........	14766.0	....	....	....	11401.0	3847.0	7554.0	....
Weight of dry matter...	3306.1	....	....	....	2552.7	2256.0	296.7	11.57
Weight of protein......	206.6	....	....	....	159.0	138.0	21.0	13.40
Silo No. 2.—Sheep's Tooth Corn.								
Weight of fodder.......	14002.0	12225.0	1777.0	....	14972.0	5142.5	9829.5	....
Weight of dry matter...	3431.5	2800.7	630.8	18.36	4689.6	3669.0	1020.6	21.77
Weight of protein.......	235 8	182.9	42.9	22.43	322.1	306.9	18.2	4.06
Silo No. 3.—Smedley Yellow Dent Corn.								
Weight of fodder........	15288.0	12151.0	3137.0	....	15464.0	5076.0	10388.0	....
Weight of dry matter...	4150.3	3373.5	776.8	16.72	3997.9	3483.0	514.9	12.87
Weight of protein.......	303.3	231.7	71.6	23.62	292.2	277.0	15.2	5.20
Silo No. 5.— Yellow Flint Corn.								
Weight of fodder.......	17218.0	14540.0	2677.0	.. ...	14890.0	4358.5	10531.5	....
Weight of dry matter...	3844.0	3355.0	489.0	12.74	4197.0	3357 0	840.0	20.02
Weight of protein.......	314.4	258.3	56 1	17.81	343.4	282.0	61.4	17.87

The great source of error in work of this kind is the difficulty of obtaining a sample which shall accurately represent the large mass of fodder used in the experiment. A single experiment may lead to erroneous results, owing to an error in taking the sample, but if we take the average of several experiments, the errors of sampling and analysis are greatly reduced, while the figures thus obtained are nearer the truth than those from any one experiment. Taking, therefore, the average of the figures given in the preceding table we have the following:

Table Showing the Average Losses in Siloing and Shocking Fodder.

	From three Silos.	From four lots Shocked Corn.
Dry matter.............	15.94 per cent.	16.54 per cent.
Crude Protein.	21.26 per cent.	10.13 per cent.

The above table shows two things: first, that with improved methods of building and filling the silo, the loss of nutritive matter is being gradually reduced. That with a tight silo and fodder at the right stage of maturity, corn can be preserved in the silo with a loss of 16 per cent. of nutritive matter. This is certainly a great gain over the destruction of 30 to 40 and even 50 per cent. of nutritive matter which was reported in the first experiments on the silo, but even this is too great for economy.

Returning to the shocked corn, we find that the results confirm these obtained last year at this Station by Mr. F. W. Woll.*

Under the exceptionally favorable conditions previously reported, the fodder corn lost 16.54 per cent. dry matter, slightly more than was destroyed by fermentation in the silo. If, under the most favorable circumstances, fodder corn can lose 16 per cent. of nutritive matter, the loss during wet years, when the corn is subject to fermentation and mould in the shock, must equal, if not considerably exceed, the loss in the silo. A loss of 36 per cent. is reported* in one case when the fodder corn began to heat and mould, and consequently had to be re-shocked.

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* Fifth Ann. Rep. Wis. Agr. Sta., p. 67-74.

ENSILAGE vs. FODDER CORN FOR MILK AND BUTTER PRODUCTION.

The following experiment was conducted for the purpose of ascertaining the relative value of fodder corn and ensilage for milk production.

PLAN OF THE EXPERIMENTS.

The experiment was divided into two periods of two weeks each, each period being preceded by a week of preliminary feeding. Four cows were used in each trial. Two cows were fed ensilage, and two others fodder corn. At the end of the first period the animals were changed over; those receiving ensilage were now given fodder corn, while the animals formerly fed fodder corn now received ensilage. This method of changing the animals so that each lot was on both sides of the experiment eliminates almost entirely the errors due to period of lactation and sudden changes in the weather, etc. The week of preliminary feeding which preceded each period, was necessary to accustom the animals to a change of feed, and to be sure that the new feed would have its full effect on the flow of milk and the weight of the animal, before the actual experimental period commenced.

The animals were weighed daily during the experiment. During which they were also given water heated to about 70° F.; the amount of water drank each day was also weighed.

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* Fifth Annual Report Wis. Agr. Exp. Sta., p. 71.

FIRST TRIAL WITH ENSILAGE VS. FODDER CORN.

The animals used in the first experiment were as follows:

Cows Used in the Experiment.

	Breeding.	Age.	Time from calving.	Weight.
Queen	Grade Jersey	5 years	15 days	775
Rose	Grade Jersey	7 years	48 days	921
Dollie	Grade Jersey	5 years	17 days	735
Bessie	Native	7 years	52 days	879

It had been noticed in previous feeding experiments that when the endeavor was made to get the fullest effect of the ensilage or fodder corn by making up the ration with but a small amount of grain feed, such as bran, oats, etc., the animals almost invariably suffered in condition and appetite. This change in the condition of the animal would necessarily have a bad effect on the milk and butter yield, and consequently would introduce an error of greater or less degree into the experiment. To obviate this error, the animals in the experiment were given what might be called a "foundation ration" of bran oats and hay, in the following proportion:

Hay	2 pounds.
Bran	4 pounds.
Oats	1 pound.

The above ration was fed daily in two feeds; with it was given as much ensilage or fodder corn as the animals would eat up clean. Under the above ration the animals remained in good condition, showing no loss either in weight or flow of milk.

The ensilage used was from silo No. 5, which contained a mixture of Yellow Dent corn and Early Yellow Flint.

The dry fodder is the same mixture, cured in the shock and stored in the barn after it had stood in the field forty days. As the fall of 1888 was unusually dry and clear, the fodder cured perfectly and was in fine condition when put in the barn. About two hundred pounds at a time were run through an ensilage cutter, stored in a dry bin, and samples taken for analysis. The ensilage was bright and sweet, free from mold, and was eagerly eaten by the cows. As the silo was emptied by feeding, numerous samples were taken, analyzed, and the average of the several samples taken for the composition of the ensilage fed.

The following table shows the results of the trial. First period Nov. 23–Dec. 16, 1888; second period Dec. 23–Jan. 16, 1889:

Table Showing the Weight of Dry Matter and Protein Eaten in Periods I and II.

	ENSILAGE.		BRAN.		OATS.		HAY.	
	Dry matter.	Protein.	Dry matter.	Protein.	Dry matter.	Protein.	Dry matter.	Protein.
ENSILAGE.								
Period I—21 days.								
Rose and Queen.....	675.7	52.02	144.1	23.94	36.01	4.32	69.93	4.89
Period II—								
Dollie and Jessie....	715.8	50.10	143.7	23.90	35.08	4.21	70.44	4.93
Total..............	1391.5	102.12	287.8	47.84	71.09	8.53	140.33	9.82
FODDER CORN.								
Period I—								
Dollie and Jessie....	648.31	51.09	144.1	23.94	36.01	4.32	69.93	4.89
Period II—								
Rose and Queen....	683.33	56.82	143.7	23.90	35.08	4.21	70.44	4.93
Total.......... ...	1331.64	102.12	287.8	47.84	71.09	8.53	140.37	9.82

Table Showing the Yield of Milk and Butter Fat, Periods I and II.

	Total milk.	Total fat.	Butter.	Butter. fat.	Per ct. fat churned out.
Ensilage.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	
Period I—					
Rose and Queen	1096.5	47.05	50.62	32.22	
Period II--					
Dollie and Jessie	728.6	38.23	33.88	25.79	
	1825.1	85.28	83.50	58.01	69.48
Fodder Corn.					
Period I—					
Dollie and Jessie	768.4	36.04	33.63	26.25	
Period II—					
Rose and Queen	975.9	51 12	44.12	32.46	
	1744.3	87.16	77.75	58.71	75.51

No of lbs. of Milk to One Pound of Butter.

Ensilage	21.83 lbs.
Fodder corn	22.43 lbs.

SECOND TRIAL WITH ENSILAGE VS. FODDER CORN.

In the second trial the conditions of the experiment were the same as in the first trial. The ensilage was from silo No. 2, which contained Sheep's Tooth fodder corn. The fodder corn was of the same variety. The ration of bran, oats and hay, was the same as in the first experiment.

The animals used were as follows:

Cows Used in the Experiment.

NAME.	Breeding.	No. days from calving.
Palmer	Grade Short-horn	35
Mattie	Grade Holstein	36
Bunn	Cross-bred Jersey and Holst'n	30
Bessie	Grade Jersey	24

The following table shows the amount of dry matter and protein eaten during the trial:

Table Showing the Amount of Dry Matter and Protein Eaten in Periods I and II.

	ENSILAGE.		BRAN.		OATS.		HAY.	
	Dry matter.	Protein.	Dry matter.	Protein.	Dry matter.	Protein.	Dry matter.	Protein.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Ensilage.								
Period I—								
Bunn and Bessie	616.0	40.16	145.48	24.18	35.70	4.28	71.88	5.02
Period II—								
Palmer and Mattie	563.0	36.22	145.90	24.26	36.06	4.32	72.04	5.04
Total	1189.0	76.38	291.38	48.44	71.76	8.60	144.92	10.08
Fodder Corn.								
Period I—								
Palmer and Mattie	658.9	43.11	145.48	24.18	35.70	4.28	71.88	5.02
Period II—								
Bunn and Bessie	607.2	34.19	145.9	24.26	36.06	4.32	72.04	5.04
Total	1266.1	77.30	291.38	48.44	71.76	8.60	144.92	10.08

Table Showing the Amount of Milk, Butter and Butter Fat Given in Periods I and II.

	Total milk.	Total fat in milk.	Total butter.	Total fat in butter.	Per ct. fat churned out.
Ensilage.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	
Period I —					
Palmer and Mattie	1088.6	42.71	46.65	37.09	....
Period II —					
Bessie and Bunn	1117.9	45.90	40,22	38.31	....
Total.....................	2206.5	92.61	86.87	75.40	81.43
Fodder Corn.					
Period I —					
Bessie and Bunn	968.7	41.66	41.79	32.76	....
Period II —					
Palmer and Mattie	1168.2	49.38	46.61	37.03	....
Total.....................	2136.9	91.04	88.40	69.79	76.67

THIRD TRIAL OF ENSILAGE VS. FODDER CORN.

The conditions of the experiment in the third trial were the same as in the two previous ones, with the following exceptions: Owing to a scarcity of ensilage, the periods were reduced to fourteen days, and the amount of hay fed was increased to four pounds per cow daily.

The animals used were as follows:

Cows Used in the Experiment.

Name.	Breed.	No. of days from calving.
Doubtful	Grade Jersey	33
Mattie	Grade Holstein	88
Beauty	Native	39
Sylvia's heifer	Grade Jersey	15

The following table shows the amount of dry matter and protein eaten during the trial:

Table Showing the Amount of Dry Matter and Protein Eaten in Trial No. III.

	ENSILAGE.		BRAN.		OATS.		HAY.	
	Dry matter.	Protein	Dry matter.	Protein	Dry matter.	Protein	Dry matter.	Protein
Ensilage.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Period I —								
Beauty and Sylvia	423.6	32.20	99.91	16.4	24.56	2.94	74.57	5.88
Period II —								
Doubtful and Mattie	477.6	36.23	98.19	16.3	24.33	2.92	74.59	5.88
Total	901.2	68.43	197.10	32.7	48.89	5.86	149.16	11.76
Fodder Corn.								
Period II —								
Doubtful and Mattie	554.7	56.1	99.91	16.4	24.56	2.94	74.57	5.88
Period II —								
Beauty and Sylvia	405.0	30.79	98.19	16.3	24.33	2.92	74.59	5.88
Total	959.7	86.80	197.10	32.7	48.89	5.86	149.16	11.76

Table Showing the Amount of Milk and Butter Fat Given in Trial III, Periods I and II.

	Total milk.	Total butter fat.
Ensilage.	*Lbs.*	*Lbs.*
Period I —		
Beauty and Sylvia	721.9	32.28
Period II —		
Doubtful and Mattie	644.4	28.72
	1,366.3	61.00
Fodder Corn.		
Period I —		
Doubtful and Mattie	721.3	29.96
Period II —		
Beauty and Sylvia	597.9	24.55
	1,319.2	54.51

DISCUSSION OF THE PRECEDING TRIALS.

In discussing the relative value of ensilage and fodder corn as shown in the three trials here given, there are several points to be considered besides the actual weight of milk and butter produced by equal weights of the dry matter of ensilage and fodder corn. The palatability of the feed, its influence on the milk flow, and condition of the animal should be considered. While perhaps the most important point of all is: How much dry matter, of corn standing in the field, is required to produce 100 pounds of milk, when the fodder is siloed; and how much, when it is field cured? Comparing the results of the first trial and remembering that 499.3 lbs. of dry matter in the form of bran, oats and hay were fed with the ensilage and fodder corn, we find that

1391.5 *lbs. of dry matter in ensilage produced* 1825.1 *lbs. of milk.*

1331.6 *lbs. of dry matter in fodder corn produced* 1744 *lbs. of milk.*

or making the calculation so that we can get a direct comparison, we find that 1,000 lbs. of milk required 762.1 lbs. of dry matter in the form of ensilage, and 763.5 lbs. of dry matter in the form of fodder corn, or a difference of only 1.4 lbs. of dry matter per 1,000 lbs. of milk in favor of ensilage.

On comparing the amount of fat produced, we find that

1391.5 *lbs. of dry matter in ensilage made* 85.28 *lbs. fat in milk.*

1331.6 *lbs. of dry matter in fodder corn made* 87.16 *lbs. fat in milk.*

or calculating as above, we find that to make 100 lbs. of milk fat would require of

Dry matter in ensilage	1632 lbs.
Dry matter in fodder corn	1524 lbs.

a difference in favor of fodder corn of 108 pounds of dry matter in producing 100 pounds of fat in milk.

In the second trial, under the same conditions as the first, but with different animals, we find that

1189 *lbs. of ensilage dry matter produced* 2206 *lbs. of milk.*

1266 *lbs. of fodder corn dry matter produced* 2136 *lbs. of milk.*

or that 1,000 lbs. of milk required of

Ensilage dry matter	539.2 lbs.
Fodder corn dry matter	602.8 lbs.

We find also that:

1189 *lbs. of ensilage dry matter produced* 92.6 *lbs of milk fat.*

1266 *lbs. fodder corn dry matter produced* 91.04 *lbs. of milk fat.*

Calculating the above to equal amounts of fat for comparison, we find that to make 100 lbs. of milk fat would require of

Ensilage dry matter	1284 lbs.
Fodder corn dry matter	1391 lbs.

a difference in favor of ensilage of 107 lbs. of dry matter in making 100 lbs. of milk fat.

In the third trial the conditions were slightly changed. The amount of dry fodder fed was slightly increased by feeding four pounds of hay instead of two pounds in the other two trials; with this exception the conditions were the same.

The table shows that:

901.2 *lbs. of ensilage dry matter produced* 1366 *lbs. of milk.*

959.7 *lbs. of fodder corn dry matter produced* 1319 *lbs. of milk.*

Consequently, each 1,000 pounds of milk required of

Ensilage dry matter	659.8 lbs.
Fodder corn dry matter	729.3 lbs.

a difference in favor of ensilage of 69.5 pounds of dry matter in producing 1,000 pounds of milk.

We also find from the tables that

901.2 *pounds of ensilage dry matter produced* 61 *pounds milk fat.*

959.7 *pounds of fodder corn dry matter produced* 54.51 *pounds of fat in milk.*

In the same proportion, 100 pounds of milk fat would require

Of ensilage dry matter	1,477.4 lbs.
Of fodder corn dry matter	1,760.6 lbs.

a difference in favor of ensilage of 283.2 pounds of dry matter in producing 100 pounds of fat in the milk. Taking these results and arranging them in a tabular form we have the following table:

SUMMARY OF PRECEDING TRIALS.

Table Showing the Amount of Dry Matter Eaten, together with the Weight of Milk and Fat in Milk, Produced in three Trials of Ensilage vs. Fodder Corn.

	Dry Matter Eaten.	Milk Produced.	Fat in Milk Produced.
	lbs.	*lbs.*	*lbs.*
Ensilage	3481.7	5397.0	238.88
Fodder corn	3557.3	5199.0	232.71
Difference	+75.6	—198.0	—6.16

The table shows that the ensilage is slightly ahead in all three points, that a greater amount of both milk and milk fat was produced with a smaller ration of dry matter in ensilage than in the case of fodder corn. The circumstances under which the above trials were carried on were peculiarly satisfactory.

As before stated, the ensilage was perhaps the best ever produced on the Station Farm; owing to the long, dry fall the fodder corn was in almost perfect condition, and far superior to that ordinarily produced.

The above, however, does not represent the actual relative value of ensilage and fodder corn. To find this, we must go further back and find how much dry matter, of corn standing in the field, the amount of dry matter, fed in the experiment actually represents. This we can do by taking into account the loss of dry matter in the silo and the shock, respectively.

Turning to page 129, we find that the average loss of dry matter in the silo was 15.94 per cent., and in the shocks, 16.54 per cent. Taking this loss into account we find that the 3481.7 lbs. of dry matter fed in the ensilage experiment represented 4142 lbs. of dry matter as standing in the field, and that the 3557.3 lbs. of dry matter fed in the fodder corn represent 4262 lbs of dry matter as standing in the field, showing that the animals fed on ensilage required 122 lbs.

less dry matter from the field than when being fed fodder corn; at the same time producing an excess of 198 lbs. of milk and 6.16 lbs. of butter fat.

CONCLUSIONS.

From our investigations we observe:

First. Notwithstanding the fact that the fall of 1888 was exceptionally dry, and well suited to the curing of fodder corn, nevertheless, the fodder shocked in the field lost a little more dry matter than that preserved in the silo. Consequently, as far as the loss of dry matter is concerned, there is little difference in the results between the method of storing fodder in small silos, as managed in this case, and that of curing in shocks during an exceptionally dry fall.

Second. There is but little difference in the feeding value of the ensilage and fodder corn when preserved under the conditions indicated above. In both cases the small differences are in favor of the ensilage.

LOSSES IN CORN STALKS DUE TO WEATHERING.

It is the custom in many parts of the country, after snapping the corn, to turn the cattle into the stalk fields, to pick up what food they may, from the bleaching and washed-out corn stalks. There is no doubt that, by this method of feeding, an immense quantity of food material is wasted, partly by the large quantity of stalks which remain uneaten, and partly by the destruction of nutritive matter through rain and frost. To gain some information on this subject the following experiment was tried.

Two plots of fodder corn, 20 feet square, were set apart at the time of cutting the corn. Two rows as nearly even as possible were sampled. One row of 20 feet was cut when the corn was ripe, the ears were removed, and the fodder weighed and sampled for analysis. The second row was allowed to stand exposed to the rain and frost for two months, then cut, the ears removed, and the fodder sampled for analysis. The following table shows the weight and composition of the samples:

Table Showing the Composition and Loss of Weathered Corn Stalks.

		Fresh.	Weathered.	Loss.	Loss.
		Lbs.	*Lbs.*	*Lbs.*	*Per cent.*
Sample I	Weight	27.00	11.25	18.75	
	Dry matter	7.84	6.84	1.00	12.76
	Protein	.663	.22	.343	59.56
	Date	Sept. 21	Nov. 14		
Sample II	Weight	28.50	10.25	18.25	
	Dry matter	8.45	6.52	1.93	22.83
	Protein	.485	.138	.347	71.55
	Date	Sept. 21	Nov. 14		

This loss falls on the most valuable part of the plant, viz., the leaves; the amount of nutritive matter left in the stalks and rendered worthless because of lack of palatability is also great. There remained, in the two cases given in the above table, over six pounds of matter which would have had a higher food value, if that part which gives palatability had not been washed out. The stalk of the corn plant, besides being the largest part of it, contains also a considerable percentage of nutritive matter. The following experiment was undertaken for the purpose of obtaining data in regard to this point.

WEIGHT AND COMPOSITION OF THE DIFFERENT PARTS OF THE CORN PLANT.

The following table shows the distribution of nutritive matter in different parts of the plant:

Table Showing the Weights of Different Parts of the Corn Plant.

Station No.	Variety.	Wt. of st'lks	No. of st'lks	Wt. of green leaves.	Wt. of dry leaves.	Total wt. of stalks free from leaves.	Wt. of lower third of stalk.	Wt. of middle third of stalk.	Wt. of upper third of stalk.	Wt. of tops.	Ears.
		Lbs.		*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Gms.*	*Gms.*	*Gms.*
465	White Flint ...	24	......	3898.0	....	4261.0	2072.0	1181.0	1008.0	97.0	2918.0
466	B. & W. ensilage	34.5	20	3916.0	499.0	9403.0	5078.0	2577.0	1658.0	94.0	775.0
467	Normandy White Giant...	22.5	11	2828.0	185.0	5163.0	2290.0	1687.0	1159.0	97.0	1221.0
468	Sibley's White Flint ...	29.75	25	2779.0	762.0	7071.0	4153.0	1905.0	1013.0	118.0	......
469	Yellow Dent ...	37.25	22	5037.0	503.0	8348.0	4641.0	2257.0	1450.0	178.0	2374.0

Table Showing Percentage Composition of Different Parts of the Corn Plant.

No.		Green Leaves.	Dry Leaves.	Butts.	Middle.	Top of Stalk.	Tops.	Ears.
465	Dry matter.......... ...	21.98	....	18.76	17.99	24.50	50.23	32.13
	Protein..................	7.31	....	4.18	5.75	5.12	6.06	10.75
466	Dry matter.............	22.46	68.01	20.6	24.85	27.30	50.23	10.93
	Protein..................	8.66	2.62	1.43	2.00	3.56	6.06	10.40
467	Dry matter.......... ...	30.13	73.81	21.45	24.52	26.96	61.58	14.83
	Protein..................	10.43	4.90	2.18	2.81	4.18	7.90	10.76
469	Dry matter...............	30.71	61.95	19.33	25.34	25.97	71.47	37,14
	Protein..................	8.56	5.12	3.56	3.60	3.50	5.74	10.13
468	Dry matter	28 67	66.39	15.98	14.95	33.11	86.26	....
	Protein..................	6.68	5.12	4.18	4.28	4.56	5.12	....

The tables show two things: first, that as before stated, the stalks from a large part of the weight of the plant, and second, that difference in composition is made up by the greater weight of the stalk in comparison with the rest of the plant. This is shown in the following table:

Table Showing the Total Weight and Percentage of Dry Matter Found in the Stalks Compared with the Rest of the Plant.

No.	Total wt. of stalk.	Total wt. of rest of plant.	Total dry matter in stalk.	Total protein in stalks.	Total wt. dry matter in rest of plant.	Total protein rest of plant.	Per ct. of total dry matter of plant in stalk.	Per ct. of protein of plant in stalk.
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*per ct.*	*per ct.*
465	4961.0	3995.0	848.1	41.11	1470.2	99.8	30.73	36.59
466	9408.0	4580.0	2162.0	44.42	850.7	87.92	69.47	33.57
467	5163.0	3100.0	1117.3	35.39	1048.2	99.87	48.50	26.18
468	7071.0	3850.0	1182.5	50.61	1406.2	84.41	45.67	37.50
469	8948.0	5718.0	1845.9	67.71	1985.9	155.6	47.08	30.00
Average.	....	....	....	.. ..	....	....	48.33	32.70

Taking the average of the five samples given in the table, we see that nearly 50 per cent. of the dry matter, and over 30 per cent. of the protein in fodder corn, is present in the much neglected stalk. No farmer can afford to allow so large a proportion of his crop to be wasted, as it is in the present methods of feeding in the field. The best way to prevent such losses will depend to a large extent on climate and location. In Wisconsin there is but little doubt that the silo, even with the loss of 25 per cent. of nutritive matter, is more economical than attempting to cure and shock corn fodder in the field. It is not so much the fact that there is large waste in shocking fodder, as it is that what is lost is the most valuable part of the fodder. Every day's exposure to wind, rain and snow tends to decrease the value of corn fodder by destroying the sugar and other soluble parts, which give to the plant its flavor and palatability. The completeness with which sweet, well cured fodder is eaten up, compared with the large amount left uneaten where badly cured, weather-beaten fodder is fed, is enough to show the value of a well flavored, well cured, palatable fodder.

CLOVER ENSILAGE.

Much of the foregoing applies with equal force to clover. There are few plants so liable to lose value during the process of curing as the clover, and even when in the barn, its liability to mustiness and mould renders its feeding qualities still more uncertain. The results obtained last winter from a silo filled with clover would seem to indicate that by siloing clover, we are able to preserve one of our most valuable crops with comparative little labor and a reasonable certainty of preserving it in the most valuable condition for feeding.

The silo was filled and covered with a layer of tarred paper and sawdust, July 19. It remained sealed till October 13, 1889, when it was opened. Some six inches of the top were found to be dry and mouldy, but below that, the clover was found to be bright and well preserved with only slight traces of mould in the corners.

The following table shows the amounts of dry matter and protein put in and taken out of the silo.

Table Showing the Amount of Dry Matter and Protein in Clover.

Clover put in silo.	Ensilage taken out.	Dry matter put in.	Protein put in.	Dry matter taken out.	Protein taken out.	Loss dry matter.	Loss protein.
Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*per ct.*	*per ct.*
12,279	9,283	4,458.6	563.1	3,772.1	490.9	15.41	12.66

The table shows a loss of 15.41 per cent. of dry matter and 12.66 per cent. of protein, much less than has been found in previous investigations. If further experiments confirm this result, this method of preserving clover will be found to be of great value.

COMPARATIVE VALUE OF WARM AND COLD WATER FOR MILCH COWS.

F. H. KING.

Whether or not it is desirable in Wisconsin, to warm water for domestic animals is manifestly not solved when the particular temperature of water best adapted to the production of milk in cows has been determined. Neither will it follow, necessarily, in case a given temperature of water shall be found to give the largest milk returns from cows, that the same temperature will also be best adapted to cattle kept for breeding purposes only, or even to beef animals. Of course it may be true that the same temperature is best for the three processes, but without specific evidence bearing upon the question it might well be anticipated that a function like that of milk production, where an annual yield of 3,000 to 7,000 lbs., much the larger portion of which is water, is produced would be most likely to be influenced by differences in the temperature of the water drank, and especially so when we remember that the cow's udder is so largely exposed and yet requires a temperature within it not far from 100° F. for its normal action. It seems desirable that these cautionary remarks should be made here, first, because the experiment here reported, which, at best, can only be regarded as prelimary, appears quite strongly to indicate a marked advantage of warm water over cold for cows giving milk during the winter season, while the reported results of three other Experiment Stations show but little or no advantage, but chiefly, because there is always a strong tendency to force conclusions far beyond the limits the data at hand will warrant. With the mind thus placed in the critical attitude there may be first presented the

PLAN OF THE EXPERIMENT.

The general plan of this experiment contemplated, as its chief object, the ascertaining whether it is true, as many farmers believe, that warm water, for milch cows, produces a measurable increase in the yield over that of cold water, and if so, whether this increase affected the volume of milk simply or the weight of total solids contained. To this end it was deemed best, as a preliminary experiment, to make all conditions, external to the cows, identical, so far as possible, except in the one item — temperature of water drank — and to use a ration which should, in itself, supply the cows with as little of the water needed daily as possible in order that the temperature of the major part of the water taken into the system might be controlled. The considerations which led to the selection of the temperatures 32° F. and 70° F. for the water drank were these: It seemed desirable that one of the temperatures chosen should be as near as practicable to the one best suited to milk production while the other should be so far removed from this one that measurable differences might be expected, for, could this be done, one set of cows would be working under normal conditions and this seemed better, with our object in view, than to have both sets of cows confessedly working continuously under abnormal conditions. In view of the fact that our mean summer temperature is about 70° F., and that cows commonly get water during this season near that temperature and do not, apparently at least, object to it, 70° was chosen for the warm water and 32° F. taken for the cold as giving the greatest difference practicable.

That the unequal action of the cows might mask the results as little as possible six were chosen and placed in two groups of three each, one of which was to receive water at 32°, while the other was to be given water at 70°, these temperatures to be reversed at intervals of suitable length which were fixed during the progress of the first period at 16 days.

To avoid the superposition of fluctuations, which might result from changing, feed upon those due to the temperature of the water, such a ration was chosen as could be maintained throughout the period without change, and the only interference with this part of the plan consisted in the necessity of substituting a variety of flint corn for the Smedley Dent, during the last five days of period III.

ANIMALS USED.

The six cows used during this experiment were Dollie, Jessie and Rose constituting group I; and Queen, Emma and Gov. Heifer constituting group II. Dollie is a Jersey; Queen 15-16 Jersey; Gov. Heifer ¾, and Rose and Jessie ½ Jersey, Emma being a native. Other facts regarding them are given below:

Name.	Breed.	Age.	Calved.	Served.
Dollie	Jersey	6 years.	Nov. 1, 1888	Dec. 7, 1888.
Jessie	½ Jersey	8 years.	Oct. 27, 1888	Nov. 28, 1888.
Rose	½ Jersey	7 years.	Oct. 1, 1888	Nov. 25, 1888.
Queen	15-16 Jersey	7 years.	Nov. 3, 1888	Dec. 18, 1888.
Emma	Native	9 years.	Dec. 10, 1888	April 2, 1889.
Governor Heifer	¾ Jersey	4 years.	Jan. 1, 1889	May 4,* 1889.

* Served also on January 29, and April 13.

It thus appears that at the close of the experiment Rose had been in milk 176 days; Jessie, 149; Dollie, 145; Queen, 142; Emma, 105, and Gov. Heifer, 84 days.

HOW THE EXPERIMENT WAS CONDUCTED.

On the evening of January 21st, the six cows were placed in stanchions side by side with a partition through the manger, separating the two groups of cows. Their feed was weighed to them twice daily, the hay and corn fodder being weighed in common to the three cows in each group, the corn fodder being always fed last and the portion not eaten weighed back. Water was given the cows but once daily, that at 70° F. being obtained by mixing water near the boiling point with that in a tub standing on the scales, enough being provided for the three cows at once, but the water was weighed to each cow separately. During the middle of the day, when the weather was suitable, the cows were allowed the freedom of the yard with the rest of the herd, being returned to the barn at 4 P. M. each day.

The milking commenced at 5:10 A. M. and 4:15 P. M., the milk from each cow being weighed separately. To avoid the introduction of apparent fluctuations in the composition of the milk by errors in the analysis, it was, during most of the time, analyzed in duplicate and the average of the two samples taken to represent the composition of the sample. In each case the samples were preserved until the results of the analysis were obtained and, if too large a difference appeared between the two analyses of any sample, a second determination was made. When the milk of each cow was analyzed separately, as it was during 31 days, the sample was obtained by taking a half pint of the night's milk and placing it in a pint self-sealing glass fruit can, adding to this another half pint from the morning's milk. When only one analysis was made of the milk of each group of cows, the night's milk from the three cows was poured together in a can and thoroughly mixed and a half pint taken from this, the morning's milk being treated in the same way to complete the sample for the day.

The cows were weighed before entering on the experiment proper on three consecutive days before watering in the morning, and also at the beginning and close of each period of the experiment.

THE RATIONS FED.

Prior to entering upon this experiment the cows had been receiving, with the general herd, hay, cut corn fodder and ensilage, together with 5.6 lbs. of bran and 2.8 lbs. of ground oats mixed. The experiment ration differed from this in containing no ensilage. Each cow received 6 lbs. of hay, 5 lbs. of bran, 2 lbs. of ground oats, mixed and what dry corn fodder of the Smedley Dent variety, cut fine, they would eat. Five days before the expiration of period III all of this variety of fodder corn was consumed and a yellow flint variety was substituted in its place during the balance of the period.

TOTAL MILK YIELD DURING EACH OF THE WARM AND COLD WATER PERIODS.

If we bring together the figures showing the total yield for each cow during each of the three periods the results will stand as given in Table No. 1.

Table 1.—*Total Milk Yield During Each of the Warm and Cold Water Periods.*

NAMES OF COWS.	GROUP I.					
	COLD WATER.		WARM WATER.		COLD WATER.	
	Milk given Jan. 25 to Feb. 9.	Average daily yield.	Milk given Feb. 18 to M'ch 5.	Average daily yield.	Milk given Mch. 10 to Mch 25	Average daily yield.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Dollie	180.9	11.30	188.1	11.75	186.7	11.66
Jessie.........	268.0	16.75	249.4	15.58	239.1	14.94
Rose	296.2	18.51	304.9	19.05	252.4	15.77
	GROUP II.					
Emma........	253.9	15.87	225.8	14.11	228.8	14.30
Gov. Heifer ..	296.9	18.55	254.5	15.90	258.0	16.12
Queen	335.7	20.98	296.3	18.52	310.8	19.42

A study of this table will reveal the fact that, with the exception of the cow Jessie, there was a smaller flow of milk while the cows were on cold water, and, it is to be noted, this is true even when no account is taken of the natural shrinkage due to the advance of the period of lactation. In the diagram, Fig. 1, the fluctuations during the warm and cold water periods for the several cows are represented on the basis of the average daily yields, the lengths of the bands being proportional to the milk given, as expressed in Table No. 1. There is appended to this diagram an additional band representing the average daily yield for each cow on the sixteen days just preceding the beginning of the experiment.

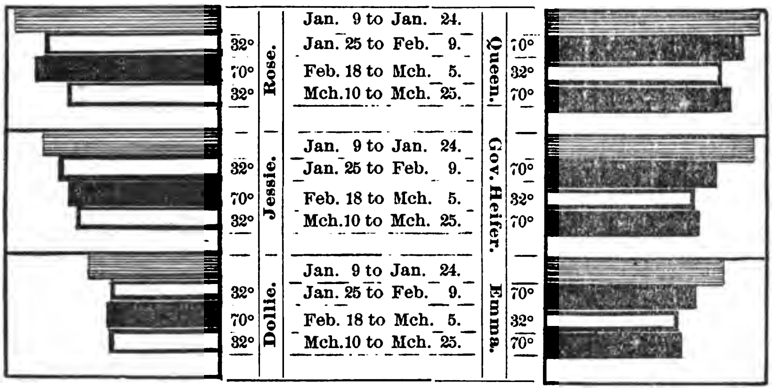

FIG. 1.

Diagram showing fluctuations in average daily milk yield for each cow on cold and on warm water. Black bands represent yields on warm, and white on cold water. The ruled bands represent the yields on the 16 days just preceding the beginning of the experiment. One inch in length represents 20 pounds.

DIFFERENCE BETWEEN THE MILK YIELD WHEN ON COLD AND WHEN ON WARM WATER.

The amount of milk given by the cows when on warm and when on cold water is, in the aggregate, markedly unequal, and to whatever this difference may be due it falls on the side of warm water as will be seen from Table No. 2, where a difference in favor of that side amounting to 226.6 lbs. is shown.

Table 2. Difference Between the Milk Yield When on Cold and When on Warm Water.

	COLD WATRR.			WARM WATER.	
	No. of period.	Lbs. milk.		No. of period.	Lbs. milk.
Group 1	I	745.1	Group I	II	742.4
Group I	III	678.2	Group II	I	886.5
Group II	II	776.6	Group II	III	797.6
Total yield		2199.9			2426.5
			Difference		226.6

This difference of 226.6 lbs. is the amount which three cows during 32 days and three others during 16 days gave while on warm water over and above that which the three cows which were 16 days on warm water gave during 32 days while on cold water, and the three cows which were 32 days on warm water gave during 16 days while on cold water.

THE QUANTITY OF WATER DRANK.

As the quantity of milk given by the cows when on warm water was greater than that given by them when on cold so was the quantity of water drank, the whole amount and the difference being shown in Table No. 3.

Table 3. The Quantity of Water Drank.

	COLD WATER.			WARM WATER.	
	No. of period.	Lbs. water.		No. of period.	Lbs. water.
Group I........	I	2974.75	Group I........	II	3492.25
Group I........	III	3087.00	Group II........	I	3540.75
Group II........	II	3020.25	Group II........	III	3516.75
Total drank ..	....	9082.00	....	....	10549.75
			Difference......	....	1467.75

It will thus be seen that during the production of 2199.9 lbs. of milk by the cows while on cold water, 9082 lbs. of water were consumed over and above that contained in the feed, or at the rate of nearly 4.13 lbs. of water to one pound of milk; but during the production of 2426.5 lbs. of milk wh warm water 10549.75 lbs. of water were taken, or at the rate of nearly 4.35 lbs. to one of milk.

THE QUANTITY OF FOOD EATEN.

If now we study the quantity of food eaten in connection with the quantity of milk produced and the quantity of water drank we shall find that, in every case, the cows which were on warm water ate the largest quantity of dry corn fodder, this being the food stuff which the cows were allowed to partake of until their hunger was satisfied. The quantity of hay, bran and oats being constant and the same for the several cows it will only be necessary to consider the quantity of dry corn fodder taken, remembering simply, that with the corn fodder the cows receive daily 5 lbs. of bran, 2 lbs. of ground oats and 6 lbs. of hay. In Table No. 4 the number of pounds of dry corn fodder consumed by the cows while on warm and on cold water is given.

Table 4. The Quantity of Food Eaten.

Cold Water.			Warm Water.		
	No. of period.	Lbs. of fodder corn.		No. of period.	Lbs. of fodder corn.
Group I	I	516.85	Group I	II	556.5
Group I	III	463.75	Group II	I	549.1
Group II	II	531.25	Group II	III	523.5
Totals		1511.85			1629.1
			Difference		117.25

This table shows that during the production of an excess of 226.6 pounds of milk, while the cows were on warm water, there was, at the same time and by the same cows, 117.25 pounds of solid food consumed more than by the cows when on cold water. To show the relation between the solid food eaten and the milk produced it will be necessary to add to each of the numbers in the table, which express the weight of dry corn fodder eaten, the quantity (5 + 2 + 6) × 3 × 16 = 624, the number of pounds of bran, oats and hay combined, eaten by each group of three cows during sixteen days. The total milk produced by the cows, while on cold water, being 2,199.9 pounds and the amount of solids consumed being 624 × 3 = 1872 pounds of hay, oats and bran, and 1,571.85 pounds of corn fodder; the solids were consumed at the rate of 1.54 pounds for each pound of milk produced. On the other hand, while the cows, during the time they were on warm water, ate 117.25 pounds more of solid food, enough more milk was given, at the same time, so that the ratio stands 1.44 pounds of solid food to one pound of milk.

THE QUANTITY OF FAT IN THE MILK.

If we now seek to determine the amount of fat in the milk produced under the influence of warm and of cold water we may do so by multiplying the weight of milk produced by the two groups during the several periods, by the per cent. of fat which chemical analysis showed the milk to contain, and in so doing we shall find the results given in Table No. 5,

Table 5. The Quantity of Fat in the Milk.

COLD WATER.					WARM WATER.				
Group.	Period.	Milk.	Fat.	Fat.	Group.	Period.	Milk.	Fat.	Fat.
		Lbs.	*Per ct.*	*Lbs.*			*Lbs.*	*Per ct.*	*Lbs.*
I	I	745.1	4.697	35.00	I	II	742.4	4.567	33.90
I	III	678.2	4.501	30.52	II	I	886.5	4.527	40.18
II	II	776.6	4.521	35.11	II	III	797.6	4.322	34.47
Totals				100.63					108.50
					Difference				7.87

which show that while, in general, the per cent. of fat contained in the milk given by the cows while on warm water was less, it was not enough lower to over-balance the greater quantity of milk given, there being a balance in favor of the warm water of 7.87 lbs. for three cows during 48 days.

THE QUANTITY OF SOLIDS NOT FAT CONTAINED IN THE MILK.

Proceeding now with the solids not fat in the same manner as that followed with the fat, we shall have the results shown in Table No. 6.

Table 6. The Qantity of Solids not Fat Contained in the Milk.

COLD WATER.					WARM WATER.				
Group.	Period.	Milk.	Solids not fat.	Solids not fat.	Group.	Period.	Milk.	Solids not fat.	Solids not fat.
		Lbs.	*Per cent.*	*Lbs.*			*Lbs.*	*Per cent.*	*Lbs.*
I.......	I	745 1	8.743	65.14	I.......	II	742.4	8.629	64.06
I.	III	678.2	8.718	59.12	II......	I	886.5	8 424	74.69
II......	II	776.2	8.295	64.42	II	III	797.6	8.348	66.58
Totals.				188.68	....				205.33
					Difference..				16.65

Here again, while in general, the composition of the milk shows that the solids not fat, like the fat, diminished in per cent. of the whole milk, yet the rate of decrease did not keep pace with the increase of yield while the cows were getting warm water.

If we compare the differences in yield of fat and of solids not fat in percentages with the cold water yields of fat and of solids not fat respectively, we shall find that the excess of fat constitutes 7.82 per cent. and the solids not fat 8.82 per cent. of their respective cold water products, so that there appears to have been a greater decrease of fat than of solids not fat, that is, the milk obtained from the cows while on warm water was relatively poorer in fat than in solids not fat.

FLUCTUATION IN THE AMOUNT OF WATER DRANK.

A study of the quantity of water taken by the several cows daily will reveal the fact that there is a somewhat marked fluctuation in the quantity of water taken from day to day by the several cows throughout the several periods. This fact appears to be specially significant since there also appears to be a fluctuation, both in quantity and composition, of the milk associated in some manner with this.

If we take the average amount of water drank daily by each cow during each period, and group those days together when the cows were taking an amount of water below the average, letting those days when the cows were taking a quantity of water above the average form a second series, we shall have, by combining them, the results given in Table No. 7,

Table 7. Fluctuation in the Amount of Water Drank.

GROUP II.	Lbs. of water drank below the average.	Lbs of water drank above the average.	Difference.	GROUP I.	Lbs. of water drank below the average.	Lbs. of water drank above the average	Difference.
Queen..........	60.704	82.666	21.962	Dollie...........	56.141	71.892	15.751
Emma..	62.169	86.301	24.132	Jessie...........	62.430	76.005	13.575
Gov. Heifer. ..	51.523	76.718	25.195	Rose....	55.114	75.130	20.016
Averages....	58.132	81.895	23.763	Averages.....	57.895	74.342	16.447

from which it will be seen that, with the exception of Dollie and Jessie, there is an average fluctuation of 23 lbs. and including those, one of 20 lbs., which is more than one quarter of the average amount of water consumed daily by each cow. The extreme fluctuation on any two consecutive days, not including the preliminary intervals, was 81 lbs. and occurred on warm water, there being, however, a fluctuation of 70 lbs. in case of cold water. The largest amount of water taken by any cow on any day within the periods was 109 lbs., there being 5 cases running above 100 lbs. The smallest amount taken on any day was 9.5 lbs., there being 11 cases below 40 lbs., all but one of which occurred with cold water, the eleven cases above 90 lbs., with one exception, all occurring with warm water, from which we may conclude that the cows manifested a preference for warm water. It should be noted in this connection, however, that the sums of the largest differences in the amounts of water taken on any two consecutive days by each of the cows in each of the three periods are nearly equal, the numbers being 372 lbs. for warm water and 357 lbs. for the cold, showing that the fluctuation is about the same with water at each of these temperatures. Possibly the existence of these large fluctuations in the quantity of water drank daily should be interpreted as meaning that cows, when on dry feed, need water more than once daily.

FLUCTUATION IN THE MILK YIELD.

If now we make a study of the daily milk yields of the several cows after the manner in which we have studied the water drank, we shall find the results indicated in Table No. 8. The results are obtained by bringing into one group the amounts of milk given on the days when the cows took a quantity of water below the average, and into a second group the amounts given when the cows drank more than the average quantity of water. As the cows were watered in every case about three hours after each milking in the morning, the milk of the succeeding evening and morning is combined with this watering.

Table 8. *Fluctuation in the Milk Yield.*

GROUP II.	Av. lbs. milk with water below average.	Av. lbs. milk with water above average.	Difference.	GROUP I.	Av. lbs. milk with water below average.	Av lbs milk with water above average.	Difference.
Queen	19.356	19.901	.545	Dollie	11.185	12.038	.282
Emma	14.598	14.886	.288	Jessie	15.612	15.894	.572
Gov. heifer	16.589	17.314	.725	Rose	17.466	18.038	.544
Averages	16.849	17.367	.519		14.754	15.323	.569

From this table it will be seen that, in every case, more milk was given, on the average, during those days when the cows took the largest quantity of water. It should be borne in mind, in considering this table and the preceding one as well, that the cows are here grouped solely on the basis of the water drank, irrespective of whether it was warm or cold.

The average difference between the quantities of milk given daily, under the conditions of large and small amounts of water drank, it will be observed, was .544 lbs., and this divided by 15.801, the average daily yield when the cows were taking least water, gives 3.44 per cent. greater yield on the large amount of water than on the small. Referring now to Table No. 7 we shall find that the average difference between the water drank daily above and below the general average was

$$\frac{16.447 + 23.763}{2} = 20.105 \text{ lbs.}$$

and this difference divided by 58.0135, the average number of pounds of water which the cows were taking daily when they were drinking the least, gives 34.65 per cent. In other words, when the cows were taking a little more than one-third more water daily they were giving three-hundredths more milk or, in the case of these six cows, while they were under experiment, increasing the water 10 lbs. in 100 lbs. increased the milk one pound in 100 lbs.

FLUCTUATION IN THE COMPOSITION OF THE MILK.

We have seen that the quantity of milk given has varied measurably with the amount of water drank. Has the composition of the milk also varied in a similar manner? Unfortunately the data collected are not in a form which enables us to test rigidly this question during each of the three periods, owing to the fact that upon entering upon the experiment it was deemed unneccessary to analyze the milk of the individual cows separately, and as the cows rarely all drank the largest and least amounts of water on the same days, it is impossible to test the question from the average composition of the milk of the two groups of cows. During period III, however, the milk was analyzed separately, and there were 16 other days when it was so treated, although these were not consecutive, so that it is possible to study the relation of the composition of the milk to the amount of water drank, during thirty-two days only. If we take each cow separately and bring those days when she was taking water below the average for period III into one group, and those when she was taking water above the average into a second group, grouping the milk analyses in the same way, we shall have the results indicated in Table No. 9, from which it will be seen, taking the averages of the six cows, that there was an increase of water in the milk amounting to .322 per cent., whereas there was a decrease in the per cent. of both fats and solids amounting in the first to .12 per cent., and in the second to .203 per cent. of the whole milk when the cows were taking water above the general average.

Table 9. Fluctuation in the Composition of the Milk.

AVERAGES FOR THE SIX COWS DURING PERIOD III, MARCH 10TH TO 25TH

Av. amount of water drank daily by the six cows.			Av. per cent. of water in the milk of the six cows.			Av. per cent. of fat in the milk of the six cows.			Av. per cent. of solids not fat in the milk of the six cows.		
In pounds above the average.	In pounds below the average.	Difference between the two averages.	Water taken above the average.	Water taken below the average.	Difference between the two averages.	Water taken above the average.	Water taken below the average.	Difference between the two averages.	Water taken above the average.	Water taken below the average.	Difference between the two averages.
79.09	58.74	20.35	87.217	86.895	+.322	4.361	4.481	—.120	8.420	8.623	—.203

There being thus quite clearly shown a dilution of the milk coincident with an increase in the amount of water drank, it is manifestly important to note the relation which exists between the quantity of water drank and the total solids contained in the milk produced.

FLUCTUATIONS IN THE TOTAL SOLIDS IN THE MILK.

If we now group the quantity of milk given by each cow daily, as we did the composition of her milk, on the basis of quantity of water drank, and then compute from the percentage composition of this milk the total number of pounds of solids produced daily by each cow, we shall have, by combining the results, the averages expressed in Table No. 10,

Table 10. *Fluctuation in the Total Solids of the Milk.*

Amt. of water drank daily by the 6 cows, in lbs.			Amt. of milk given daily by the 6 cows, in lbs.			Amount of fat given daily by the 6 cows, in lbs.			Amt. of solids not fat given daily by the six cows, in lbs.		
Above av.	Below av.	Diff.	Most.	Least.	Diff.	Most.	Least	Diff.	Most.	Least	Diff.
Sums of Averages for the 6 cows during period III, March 10-25.											
474.54	352.46	122.08	93.249	91.073	2.176	4.046	4.113	—.67	7.822	7.832	.01

from which it appears that while the six cows during period III were giving, in the aggregate, 2.176 lbs. more milk per day, on the average when they were taking most water, the absolute amounts of fat and of solids not fat were, if anything, a trifle less than those produced when they were taking least water per day.

If we take the average amounts of fat given daily by the six cows and compute what they would aggregate during 48 days for three cows, we shall have 1.608 lbs. of fat as the balance in favor of the smallest amount of water drank. In Table No. 5, however, where the cows are grouped on the basis of warm and cold water, the difference, when expressed properly for comparison here, is 6.727 lbs. in favor of the warm water, which is also largest in amount; there being thus a discrepancy amounting to 6.727 lbs. + 1.608 lbs. = 7.335 lbs. to be accounted for.

INFLUENCE OF TEMPERATURE OF THE WATER DRANK ON THE COMPOSITION AND QUANTITY OF MILK.

We have seen that when the milk given during Period III was grouped on the basis of the quantity of water drank by the cows daily, there was no gain in the total solids produced although the cows, when taking most water, actually gave at the average rate of 2.176 lbs. more milk, in the aggregate per day. It is impossible to group the milk yield of this period on the basis of temperature alone and eliminate the individuality of the cows, because three of them took warm water and the other three cold during the 16 days. There were, however, 16 days during which the milk of each cow was analyzed separately, and during these, one group was 10 days on warm water and 6 days on cold, while the other was 10 days on cold and 6 days on warm, so that it is here possible to partially eliminate the individuality of the cows and group the milk on the basis of warm and cold water simply.

To study this phase of the question it will be best to ascertain, first, the difference in the yields of solids when only the quantity of water drank is the variable element, and to do this we must set the yields on warm water in one series and the yields on cold water in another, dividing each into two groups, one when the cows were taking water below the average and the other when they were taking water above the average. By making this distribution and combining the results we get the facts expressed in Table No. 11, from which it will be seen that while the six cows were on warm water and, in the aggregate, taking 118 lbs. of water daily more than when they were taking water below the average, they were giving 4.449 lbs. more milk and .178 lbs. more fat daily; but when the same cows were on cold water and taking in the aggregate 157 lbs. more water daily than when they were taking water below the average (though, absolutely, the six cows were drinking 77.5 lbs. less daily than when they were having warm water), they were giving 6.128 lbs. more milk and yet only .138 lbs. more fat when they were taking cold water above the average than when they were taking it below the average.

Table 11.—*Showing aggregate amounts of water drank, milk and fat given daily and per cent. of fat in the milk for six cows during the* 12 *days, Feb.* 7–9 *and* 16–19 *and March* 1 *and* 2, *and* 7–9.

POUNDS OF WATER.			POUNDS OF MILK.			PER CENT. OF FAT IN MILK.		POUNDS OF FAT.		
Above average.	Below average.	Diff.	Most.	Least.	Diff.	Most.	Least.	Most.	Least.	Diff.
Most water at 70° against least water at 70° F.										
510.84	392.62	118	97.668	93.189	4.449	4.4564	4.478	4.3511	4.173	.178
Most water at 32° against least water at 32° F.										
452.57	295.86	157	91.529	85.401	6.128	4.5655	4.7314	4.179	4.041	.138
Water at 70° F. against water at 32° F.										
70° 451.73	32° 374.21	77.5	70° 95.148	32° 87.898	7.25	70° 4.4825	32° 4.6484	70° 4.265	32° 4.084	.181

We are thus enabled to see that when these cows were on cold water not only were they giving absolutely at the rate of 7.25 pounds of milk less per day, in the aggregate, than when they were on warm water, but the milk which was produced on the maximum amount of cold water, when compared with that produced on the minimum cold water, was relatively much less rich in fats than was that produced upon the maximum amount of warm water, when compared with that obtained when the least warm water was being taken. By dividing the excess of fat produced daily when the cows were taking the most warm water by the total amount of fat produced when they were taking least we shall have

$$.178 \div 4.173 = 4.26 \text{ per cent.}$$

as the advantage associated with the excess of warm water.

Similarly, by dividing the excess of fat produced daily by the six cows when they were taking most cold water, by the total amount produced when they were taking least cold water we shall find

$$.138 \div 4041 = 3.41 \text{ per cent.}$$

as the advantage associated with the large amount of cold water drank.

If now we pay no attention to the quantity of water drank and place all the milkings, during the twelve days under consideration, which were produced under the influence of water at 32° F. in one series, and those produced under the influence of water at 70° F. in another, we shall find, as shown in Table No. 11, that notwithstanding the fact that the difference between the amount of water drank was only 77.5 lbs., yet the difference in the amounts of milk given was 7.25 lbs. We shall also have

$$.181 \div 4.084 = 4.43 \text{ per cent.}$$

as the advantage associated with the water at 70° F.

The results now stated, taken at their face value, suggest the conclusion that the temperature of the water, rather than increased amount drank, is really the dominating factor in influencing the total amount of solids produced, but the interval which they cover is too short and contains too many irregularities to place great confidence in these indications taken by themselves.

The chance for error on this point, supposing that we are not dealing with a mere coincidence, lies in the fact that the percentage composition of the milk during the 12 days under consideration, may not be applicable, as an average, to the three periods collectively. The fact that the percentages are obtained from milkings coming in the middle of the three periods is in favor of their being applicable, but it is possible to test their value numerically in this way:

We have the actual amount of fat produced by the six cows during the three periods as determined by the amount of milk given and the percentage composition of the milk as determined by analyses, this being 209.13 lbs., as given in Table No. 5. If now we group all the milk given during the three periods on the basis of most and least water drank, as it has been grouped for the 12 days under consideration, we shall be able to apply the percentage composition of the milk, as determined from the 12 days, to the whole quantity of milk given and see how far the results thus obtained depart from the actual amounts. The amount of milk produced by the cows on most warm water was 1187.2 lbs., and multiplying this by the average percentage of fat in the milk when the cows were taking most warm water, during the 12 days given in Table No. 11, we have

1187.2 lbs. milk × 4.4564 per cent. of fat = 52.906 lbs. of fat.

Proceeding in the same way we get from the milk produced on the least amount of warm water

1239.2 lbs. of milk × 4.778 per cent. of fat = 55.491 lbs. of fat.

The milk from most cold water gives us

1183.6 lbs. of milk × 4.5655 per cent. of fat = 54.037 lbs. of fat,

and that from the least gives

1016.3 lbs of milk × 4.7314 per cent. of fat = 48.085 lbs. of fat.

Combining these results we get, for the warm water,

52.906 lbs. + 55.491 lbs. = 108.397 lbs. of fat, the actual amount, as given in Table No. 5, being 108.5 lbs.

From the cold water we get

48.085 lbs. + 54.037 lbs. = 102.122 lbs. of fat, the actual being 100.63 lbs.

It is thus seen that the per cent. of fat found in the milk from most and least cold and warm water for the 12 days under consideration is fairly applicable to the milk as a whole, the per cent. for the milk from cold water being a little too high. It is not likely that this error is one of analysis because each cow's milk was analyzed separately and with but few exceptions, in duplicate, each of the above percentages being an average of 80 milk analyses. The abnormal shrinkage in the milk yield during the closing part of period I, which is shown in Table No. 18, has certainly contributed somewhat to this high percentage.

If now we take into consideration the whole milk of the three periods, grouping it in three ways; first, that produced under the influence of water at 32° F. against that produced uner the influence of water at 70° F., second, that propuced under most water at 70° against that produced under least water at 70°, and third, that produced under most water at 32° F. against that produced under least water at 32° F., and use on the second and third groups the fat percentages determined from the twelve days we shall get the results given in table No. 12.

Table 12.—*Showing Aggregate Amounts of Water Drank, Milk and Fat Given Daily and Per Cent. of Fat in the Milk for the Six Cows During Periods I, II and III.*

POUNDS OF WATER.			POUNDS OF MILK.			PER CENT. OF FAT IN MILK.		POUNDS OF FAT.		
Above Average.	Below Average.	Diff.	Most	Least.	Diff.	Most.	Least.	Most.	Least.	Diff.
Most water at 70° F. against least water at 70° F.										
503.30	374.52	134	101.76	100.475	1.285	4.4564	4.478	4.535	4.494	.041
Most water at 32° F. against least water at 32° F.										
424.10	321.09	103	93.442	89.673	3.769	4.5655	4.7314	4.266	4.243	.023
Water at 70° F. against water at 32° F.										
70°	32°	......	70°	32°	......	70°	32°	70°	32°	.....
441.41	372.59	69	101.104	91.662	9.442	4.472	4.573	4.521	4.192	.329

Here we have results more reliable than those given in Table No. 11, in so far as the time is four times as long, but it is open to criticism owing to the fact that one set of cows was twice on cold water while the other was twice on warm water. The error thus introduced may, to a large extent, be eliminated by doubling the single periods making, so far as that is possible, the equivalent of four periods of 16 days each. When this is done the results given in the last table will appear as given in Table No. 13.

Table 13. Showing the aggregate amounts of water drank, milk given daily and per cent. of fat in the milk for the six cows, during Periods I, II and III, and an estimated Period IV.

POUNDS OF WATER.			POUNDS OF MILK.			PER CENT. OF FAT IN MILK.		POUNDS OF FAT.		
Above average.	Below average.	Diff.	Most.	Least.	Diff.	Most.	Least.	Most.	Least.	Diff.
Most water at 70° F. against least water at 70° F.										
501.60	376.00	125	99.4375	98.612	8.25	4.4564	4.478	4.431	4.416	.015
Most water at 32° F. against least water at 32° F.										
422.73	315.93	107	94.783	91.063	3.72	4.5655	4.7314	4.328	4.308	.020
Water at 70° F. against 32° F.										
70° 438.80	32° 369.33	69	70° 99.028	32° 93.016	6.012	70° 4.4957	32° 4.560	70° 4.452	32° 4.242	.210

This table shows that with water at 70° F. an aggregate difference of 125 lbs. of water is associated with a daily difference of only .015 lbs. of fat on six cows, and 107 lbs. of water at 32° F. is associated with a fat yield of .02 lbs. in favor of most water; while a difference of only 69 lbs. of water, but with a difference in temperature of 38° is associated with a difference of .21 lbs. of fat daily in favor of the highest temperature, so that the case appears fairly strong in favor of the high temperature of water rather than the large quantity as increasing the total production of solids in milk with cows during the cold winter weather in Wisconsin.

AMOUNT OF HEAT REQUIRED OF THE COWS TO WARM THE WATER THEY DRANK.

We have seen from Table No. 3, that, during 48 days, three cows drank 9082 lbs. of water at a temperature of 32° F. and that three others drank 10549.75 lbs. at 70° F. during the same number of days. What is the difference between the amounts of heat which it became necessary for the cows to generate within their bodies to raise the temperature of the water up to blood heat? The normal temperature of the cow is given as ranging between 101° and 102° F. The cows when taking water at 32° were required to raise its temperature through at least 100° − 32° = 68° F.; while when they were taking water at 70° the elevation of temperature extended through 30° only.

One unit of heat is the amount required to raise one pound of water from 32° to 33° F., and would be produced, according to Frankland, by the perfect burning of .4286 grains of dry beef fat. At the same rate the heat value of one pound of beef fat would be 16331 heat units, which, by perfect burning and utilization of the heat generated, should warm

16331 lbs. ÷ 68 = 240.16 lbs. of water from 32° F. to 100° F. and

16331 lbs. ÷ 30 = 544.36 lbs. of water from 70° F. to 100° F.

The cows while on cold water averaged 63.03 lbs. of water daily and the amount of heat which a pound of dry beef fat is capable of generating would, at this daily average, suffice for

240.16 ÷ 63.03 = 3.81 days for one cow.

The cows while taking water at 70° drank a daily average of 73.135 lbs., and the amount of heat which a pound of beef fat is capable of yielding would suffice to warm the necessary water, taken at 70° F., for one cow during

544.36 ÷ 73.135 = 7.44 days,

which is 1.95 times as long as that required when water is taken at 32° F.

The question naturally arises here whether the extra amount of milk given by the cows taking warm water is capable of producing an amount of heat equal to the extra amount of heat which was required to warm the water taken at 32° F.

Neglecting the slight variation in the specific heat of water between 32° F. and 100° F., we shall have the number of pounds of water drank at 32° F. multiplied by the number of degrees through which it became necessary for the cows to raise its temperature in order to bring it up to blood heat, or

9082 × 68 = 617576 heat units

as the amount the cold water cows were required to generate for the purpose of warming water.

The cows on warm water would have been required to generate

10549.75 × 30 = 316492.50 heat units,

in raising the water drank at 70° F. to a temperature of 100° F., and

617576 heat units — 316492.50 = 301083.5 heat units,

the amount the cows, while taking water at 32° F., were obliged to supply from their bodies over and above that which was necessary for the cows taking water at 70° F. to supply.

If we take Frankland's results for the heat value of milk as applied to milk given by these cows and multiply the heat value of one pound of milk by the number of pounds of milk which the cows on warm water gave more than those on cold water did, we shall have

1148 heat units × 226.6 = 260136.8 heat units,

as the value of the excess of milk given on warm water, and finding the difference between this and the extra heat the cows on water at 32° F. were obliged to supply, we shall have

301083.5 — 260136.8 = 40946.7,

which is the number of heat units the 226.6 pounds of milk falls short of equaling. That is to say, had the cows, while on warm water, done as much work in producing more milk as the cows on cold water did in heating water, they would have produced

40946.7 ÷ 1148 = 36.5 more pounds of milk than they did.

It is not supposed that this close approximation to an equality in values is anything more than a coincidence, but it is important to keep in mind that an amount of work was done in the bodies of the cows in heating 9082 pounds of water through 38° F., at the expense of food eaten, which it was not necessary to have done in the bodies of the cows when taking water at 70° F. and that, for this reason, the cows which did not expend so much food in warming water should be expected to do an equivalent amount of work of some other sort which, in this case, happens to be so nearly accomplished in the production of 226.6 pounds more milk.

THE MILKING MOST INFLUENCED BY THE QUANTITY OF WATER DRANK.

It is a matter of interest to know how long after the water is taken, its maximum effects on the production of milk are produced, but the data obtained from this experiment are only sufficient to offer a suggestion.

Owing to the milk production interval, for the first milking after watering, being only 11 hours 5 min., and that for the second being 12 hours 55 min., so far as time simply is a factor, we should expect the second milking to be larger than the first.

If we group the first and second milkings after watering by themselves, on the basis of water drank above and below the general average for each of the three periods, we shall have the results indicated in Table No. 14,

Table 14. *Showing the average amount of water drank daily, and of milk given at the first and second milkings after watering.*

	POUNDS OF WATER.		1ST MILKING.			2ND MILKING.		
	Above average	Below average	Most.	Least.	Diff.	Most.	Least.	Diff.
Queen	82.666	60.704	9.075	9.094	—.019	10.825	10.262	+.563
Emma	86.301	62.169	6.730	6.653	+.077	8.155	7.945	+.210
Gov. Heifer	76.718	51.523	7.928	7.750	+.178	9.386	8.839	+.547
Dollie	71.892	56.141	5.530	5.270	+.260	6.508	5.914	+.594
Jessie	76.005	62.430	8.114	7.734	+.380	7.779	7.877	—.098
Rose	75.130	55.114	8.445	8.319	+.126	9.592	9.145	+.447
Averages	78.118	58.013	7.637	7.470	+.167	8.707	8.330	+.377

from which it will be seen that the second milkings are larger than the first, but they are not enough larger than the first to have the same numerical relation between them as exists between the time intervals for the two milkings. The numerical relations existing between the actual milkings and what they would be, supposing the amounts of milk to be proportional to the lengths of the time intervals, are expressed below,

With Water Above the Average.

	First Milking.	Second Milking.
	Lbs.	*Lbs.*
Actual yield with most water	7.637	8.707
Computed yield	7.54775	8.79625
Difference	+.08925	— 08925

With Water Below the Average.

	First Milking.	Second Milking.
	Lbs.	*Lbs.*
Actual yield with least water	7.470	8.330
Computed yield	7.296528	8.5034722
Difference	+.1734722	—.1734722
General average	+.13136	—.13136

from which it appears that the actual yields of the first milkings, both on most and on least water drank, are larger than the computed yields, while the second milkings are smaller than they would be if the amounts were proportional to the lengths of the time intervals. The difference between the actual and the computed yields is greatest when the cows were taking water below the average, and least when they were taking water above the average, this being about .09 of a pound in the case of most water and .17 with the least. It is entirely possible and perhaps even probable that this quantitative relation has no direct connection with the amount of water drank, but the fact that the relation was not the same when the cows were taking water below the average quantity as it was when more water was drank suggests that the two may be in some way related.

DAILY FLUCTUATION IN THE PER CENT. OF WATER IN THE MILK COINCIDENT WIH THE QUANTITY OF WATER DRANK.

If we consider, in couplets, the quantity of water taken and milk given by each cow, during the two milkings immediately following the drinking of the water, for the 25 days from March 1 to the 25th, inclusive, when the milk was analyzed separately and in duplicate for each cow, we shall find, for each of the six cows, that in the majority of cases an increase in the amount of water drank is followed by an increase in the per cent. of water in the milk given at the two milkings which follow the taking of the water. The curves for these fluctuations have been plotted for each of the cows and are represented in Fig. 2, from which it will be seen that the coincidences between an increase of water drank and an increase of water in the milk stand numerically as follows:

Cows on Warm Water.

	Coincident.	Not coincident.
Emma	20	5
Queen	19	6
Gov. Heifer	21	4
Total	60	15

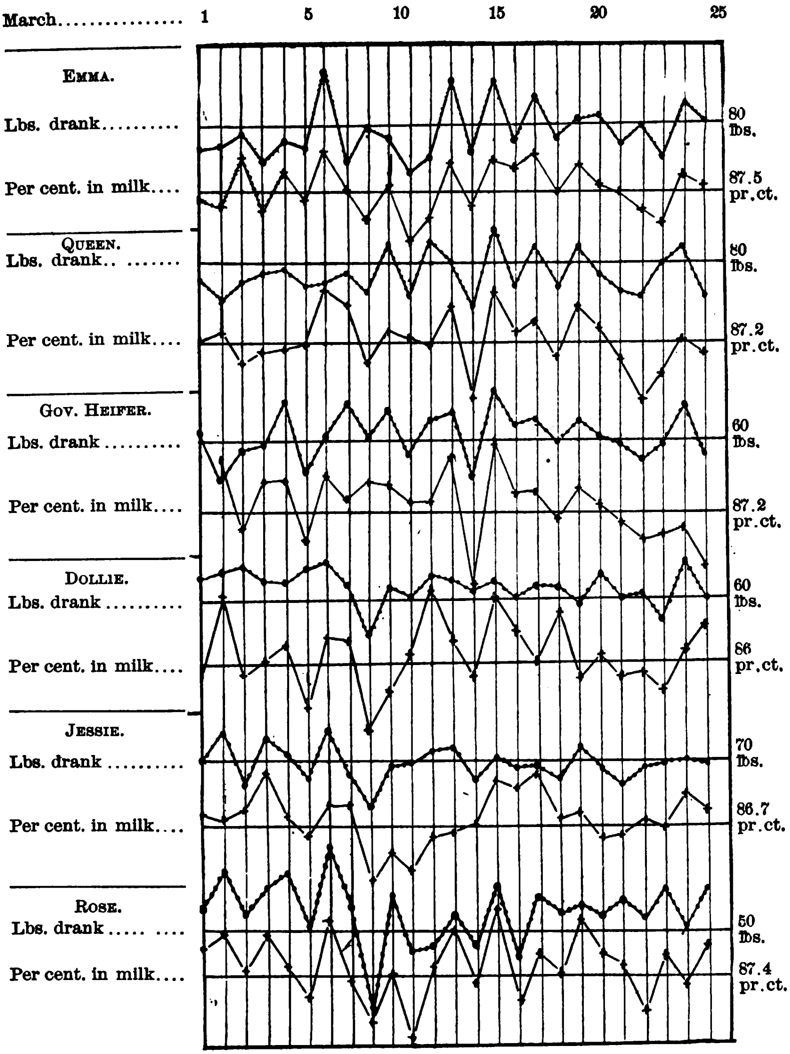

Fig. 2.

Showing fluctuations in the per cent. of water in the milk and in the amount of water drank. The upper curve, in each case, represents the daily fluctuations in the amount of water drank, and the lower one represents the fluctuations in the per cent. of water in the milk.

Cows on Cold Water.

	Coincident.	Not coincident.
Rose	23	2
Jessie	18	7
Dollie	17	8
Total	58	17

It is evident that it does not follow, necessarily, because the percentage of water in the milk runs up coincidently with the amount of water drank, that the variation in the water drank is the real cause of the change in the percentage composition of the milk, for there may be some other condition operating which tends both to cause the amount of water to vary and at the same time the composition of the milk as well. The fact, however, that the two cows, Jessie and Dollie, which have fluctuated least in the amount of water drank daily, show the smallest number of coincident changes suggests that, whatever other causes may have been operating tending towards these fluctuations, the water exerts a specific effect of its own tending to cover up the others.

INFLUENCE OF THE AIR TEMPERATURE ON THE PERCENTAGE COMPOSITION OF THE MILK.

We have seen that our results appear, at least, to indicate that the heat carried by the water drank, contributed more toward a large yield of solids in the milk than did the extra amount of water which was taken at 70° F., and this naturally raises the query whether or not fluctuations in the air temperature also exerted a measurable effect upon the total product of solids given by the cows. In other words, whether the lowest temperatures applied to these cows externally, like those which were applied internally by the water, also tended to decrease the total solids produced.

If we plat the external and internal stable temperatures for the 25 days just considered they will appear as represented in Fig. 3, where the water and the milk curves for Dollie, Jessie and Rose are also shown for comparison. A study of these curves will show that, while there is certainly no daily coincidence between the fluctuations, there are strong resemblances between the five curves which are most marked in the cases of Dollie and Jessie, the cows least affected by the water. It could hardly be expected that the direct effect of changes in the temperature of the air could be either as pronounced or as immediate as would those of the large quantities of water taken internally, and hence the coincidences could not be expected to be diurnal but only of longer periods where strong contrasts of temperature occur. Besides, if an abundance of pure air, like an abundance of good food, contributes toward larger milk yields, the ventilation being better, as a rule, on cold days than on warm, would tend to diminish the influence of the low temperature.

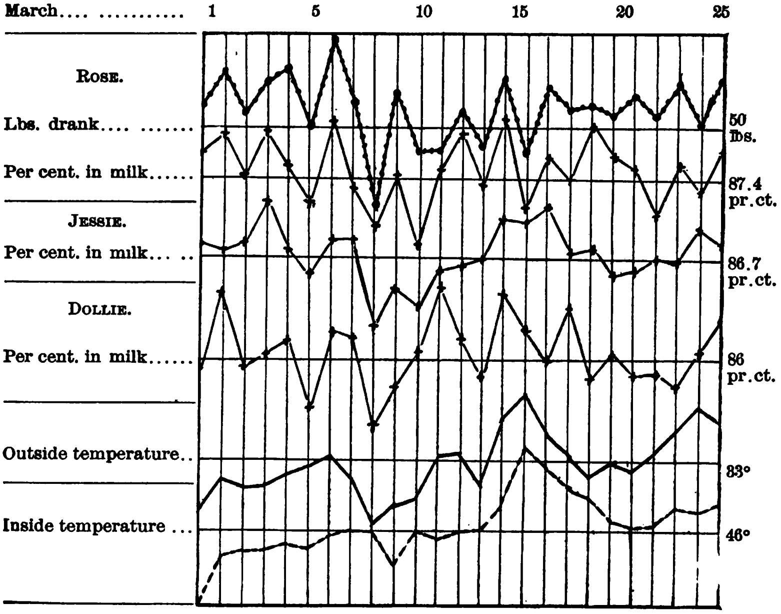

Fig. 3.

Showing the relations between the fluctuations in the amount of water drank, per cent. of water in the milk, and the mean daily temperature.

PREFERENCES OF THE COWS FOR WARM AND COLD WATER.

An effort was made at the close of each of the periods of the experiment to ascertain whether the cows, of their own choice, would take water at one temperature in preference to that at another. The trial was made by taking two pails of water, one at the temperature of 32° F. and the other at 70° F. and placing before the cow, first the water whose temperature was that which she had been taking during the period just closed. After allowing her to swallow two or three times this pail was replaced by the other and after she had tasted it the two were placed side by side before her. The results were these:

Gov.'s Heifer, whether she had been on warm water or on cold, invariably chose the iced water in preference to the warm, and so strong were her preferences that she tried to get water from the barnyard on one day when the snow was melting. It must be noted, however, that this cow gave most milk and solids on the water whose temperature she disliked.

The other cows always preferred the water at 70° to that at 32°, but if they were just going off a cold water period they would usually drink indifferently from either pail until thirst was partly slacked, after which they would always refuse the iced water. The cows going off water at 70° would always refuse the water at 32°.

The cows' preferences for water at the ordinary temperature of water in the well, as compared with that for water at 32° and 70°, were also tested with the result that, except Gov. Heifer, the water at 70° was chosen by all the cows at the close of the second period.

On the 26th of March, as the cows were taken off the experiment and when the temperature of the air was 48.7° F., the cows were offered their choice between water at 32° and 43° and between 70° and 95°. On this trial Rose drank indifferently of water at 95° and 70°, Dollie showed a slight preference for water at 70° over that at 95°, and Jessie refused the 95° and took 43° in preference to 70°. These three cows had been taking water at 32°. Emma, Queen and

Gov. Heifer which had been taking water at 70° during the last period disliked the water at 95°. When water at 43° and 70° were set before Emma she drank first from the coldest but returned to the warmest. Queen took water at both 43° and 32° showing a preference for that at 43°, but when water at 70° was offered her she took that at 32° instead. Gov. Heifer manifested a slight preference for water at 43° instead of that at 32°.

Using the cows' preferences as a basis for judgment they appear to indicate that, in the majority of cases during cold weather, cows would prefer water at 70° to that at 32° or 43°, but some like it best at 32°. When the weather becomes warmer and reaches 48° to 50° F. their preferences for water at 70° are less strong and at such times only exceptional cows, if any, would choose water at 95° F.

The fact that two of the cows which had been taking cold water during the last period chose warm water instead, and that the three cows which had been taking warm water either preferred cold to warm, or showed but slight preference for it, suggests that even should it be finally settled that it pays to warm water for cows in winter, it may also be desirable to have cold water where the cows can have it for a change.

There is another set of facts which may be presented as indicating both a preference on the part of the cows for water at 70° F. over that at 32° and a possible advantage to be derived from a change of temperatures. They are these: If we determine the average amount of water drank daily by each cow during the first five days of each period and compare these with the averages of the last five days of each period we shall find that while the cows were on cold water they took on the average nearly 5 lbs. more water each, daily, during the first five days than they did during the last five days; while when on warm water the average for both sets of days is sensibly the same, suggesting that these cows tired sooner of the water at 32° than of that at 70° F.

WILL IT PAY TO WARM WATER FOR MILCH COWS IN THE WINTER?

It is the purpose here to consider this question only from the standpoint of the data of the experiment under consideration, basing the estimates on the observed differences in the amount and composition of the milk produced under the influence of water at 32° F. and at 70° F.

Considering first the actual differences in the amount of milk, as shown in Table No. 2, it will be observed that 226.6 lbs. stand to the credit of warm water as the gain made by three cows in 48 days. This is at the rate of a little more than 1.57 lbs. of milk per cow per day and 15.7 lbs. per day on a herd of 10,; 31.4 lbs. on a herd of 20 and 62.8 on a herd of 40 cows respectively. Extending these daily gains over the interval from Dec. 1 to March 31, the result will stand as given below:

Gain in Pounds and Quarts of Milk During 120 *Days for* —

1 Cow.	10 Cows.	20 Cows.	40 Cows.
188.4 lbs.	1884. lbs.	3768. lbs.	7536. lbs.
87.72 qts.	877.2 qts.	1754.4 qts.	3508.8 qts.

The product of these results by the market value of milk per pound or quart is the cash value of these gains, and constitutes a portion of the data which our farmers who are supplying milk to customers by the quart need in considering whether, for them, it will pay to warm water for their cows.

Referring now to Table No. 5, it will be seen that there was a total gain of 7.87 pounds of fat standing to the credit of warm water, as the product of three cows during forty-eight days. This is at the rate of a little more than .055 pounds of fat per cow per day and .55 pounds for ten cows, 1.1 pounds for twenty cows, and 2.2 pounds for forty cows per day. Extending these results over a period of 120 days as was done before, we shall have the results given below:

Gain in Pounds of Fat and Skimmed Milk During 120 *Days for*—

1 cow.	10 cows.	20 cows.	40 cows.
6.64 lbs. fat.	66.4 lbs. fat.	132.8 lbs. fat.	265.6 lbs. fat.
181.76 lbs.	1817.6 lbs.	3635.2 lbs.	7270.4 lbs.

If we assume that the solids not fat and water contained in merchantable butter are equal in weight to the fat not recovered from the milk in skimming and churning, then the product of the number of pounds of fat into the market value of butter per pound plus the product of the number of pounds of skimmed milk into the feeding value of skimmed milk per pound constitute a part of the data needed, by farmers who are making butter in the winter, to ascertain whether it will pay them to warm water for their cows.

It has been stated that the values which stand to the credit of warm water in Tables Nos. 1 and 5 which we have used in these computations are too large. Had the differences which have been considered resulted from setting two groups of cows having equal productive capacities against each other no correction would have been necessary. So, too, had it been practicable to have carried the experiment through four periods instead of three the results would have required fewer corrections than are now necessary, and it is because only approximate corrections can be applied to these tables that the actual differences have been considered first.

The facts are the group of cows which was twice on warm water proved to be the largest milkers, and this being true, the differences which appear in favor of warm water are larger than they would otherwise have been. This error can, to a large extent, be eliminated by doubling the results obtained during the cold water period of Group II and the warm water period of Group I. When this is done, the milk which stands in favor of warm water is 192.4 lbs.

and the fat 6.727 lbs., and these differences are for three cows during 64 days instead of 48 days, the number of days the cows were actually under experiment.

Considering first the advantage of warm water over cold on milk production, computing from the corrected basis given above, we shall have 192.4 lbs. of milk standing to the credit of warm water as the gain made by three cows during 64 days. This is at the rate of 1.002 lbs. per day per cow and 10.02 lbs. per day on a herd of 10, 20.04 on a herd of 20 and 40.08 on a herd of 40 cows respectively. Extending these daily gains over the interval from December 1, to March 31, the results will stand as given below:

Gain in Pounds and Quarts of Milk During 120 *Days by*—

1 cow.	10 cows.	20 cows.	40 cows.
120.24 lbs.	1202.4 lbs.	2404.8 lbs.	4809.6 lbs.
55.86 qts.	558.6 qts.	1117.2 qts.	2234.4 qts.

These figures represent very closely an actual gain, which, to say the least, was coincident with the consumption of warm water whether it was due to it or not.

Taking now the fat which, on the corrected basis, stands to the credit of warm water, we have 6.727 pounds of fat as the gain made by three cows during sixty-four days. This is at the rate of .035 pounds per cow per day, and .35 pounds per day for ten, .7 pounds for twenty, and 1.4 pounds for forty cows. Extending these gains over an interval of 120 days we have the results expressed below:

Gain in Pounds of Fat and Skimmed Milk During 120 *Days by*—

1 cow.	10 cows.	20 cows.	40 cows.
4.2 lbs. fat	42.04 lbs. fat	84.08 lbs. fat.	168.16 lbs. fat.
116.04 lbs.	1160.4 lbs.	2320.8 lbs.	4641.6 lbs.

Now whether or not these gains are sufficiently large to pay for warming the water, manifestly depends upon a variety of circumstances such as the current price of butter, fuel, feed and labor, and whether or not warm water tends to prolong the period of lactation.

We have seen, from Table No. 4, that the cows while on warm water consumed 117.25 lbs. more dry fodder corn than did the cows when taking cold water, and this amount, corrected as we have corrected for the amounts of fat and milk, gives an average of .74 lbs. per cow per day of dry, unhusked, cut fodder, and 7.4 lbs. per day for 10, 14.8 lbs. for 20 cows, and 29.6 lbs. for 40 cows, respectively. Extending these amounts of feed over a period of 120 days we have the results expressed below:

Extra Amount of Corn Fodder Eaten in 120 Days by—

1 cow.	10 cows.	20 cows.	40 cows.
88.8 lbs.	888 lbs.	1776 lbs.	3552 lbs.

And whatever the current price of the extra feed eaten may be, that, multiplied by the number of pounds consumed, will give one of the debit items in the account.

The cows, while on warm water drank, in the aggregate, in 48 days, 10549.75 lbs., or a daily average of 73.26 lbs. per cow, and if this is to have its temperature raised from, say 40° F. to 70° F., the number of heat units required would be

$$73.26 \times 30 = 2197.8,$$

whose equivalent would be obtained in burning the solids of 1.9 lbs. of milk, and the question is, whether we can generate this heat more cheaply independently of the cow than we can within her body. The fuel value of one pound of water-free non-resinous wood, such as oak or maple, has been found to be 15873 heat units; that of ordinarily dry wood, not sheltered, containing 20 per cent. of water, is 12272 heat units.

Taking the last number as expressing the heat value of one pound of wood, the amount of wood required to warm the water for the cows would be as given below:

Theoretical Amount of Non-Resinous Wood Containing 20 *per cent. of Water Required to Warm Water* 120 *Days for—*

1 Cow.	10 Cows.	20 Cows.	40 Cows.
21.49 lbs.	214.9 lbs.	429.8 lbs.	859.6 lbs.

And these numbers multiplied by the current price of wood would give a cost, with this kind of fuel, below which it is impossible to go in warming the water. It is certain that the cost must always be more than these figures would indicate, but how much it is impossible to say except by actual trial. Were kerosene at 14 cents per gallon to be used, the cost per cow for 120 days could not be less than 12 cents, and for 40 cows $4.80 for fuel.

Taking the price of butter at 20 cents per pound and skimmed milk at 25 cents per cwt., the total cost of heating water for 40 cows during 120 days at $15, and the cost of the corn fodder cut fine at $5 per ton, the account would stand:

	Dr.	Cr.
To heating water	$15.00	....
To 1.776 tons corn fodder	8.88	....
By 168.19 lbs butter	....	$33.64
By 46.4 cwt. skimmed milk	....	11.60
Balance in favor warm water	....	$21.36

Taking everything into consideration, the debit side of this account is as large as it is likely to be under reasonably careful management, and a herd of 20 cows, if the results of this experiment can be realized in general practice, ought to yield a margin of $10, and as this is 7 per cent.

interest on $428.57 for the 120 days under consideration it is worth saving.

It must be remembered, however, that this experiment has been tried with water at 32° F. on one side, whereas it is entirely practicable to supply water to cows fully 10 degrees higher than this in most parts of the state without the application of heat, and should the difference between water at 42° F. and water at 70° F. prove to be much less than that obtained on this experiment, the heating of water for cows giving milk could not be regarded a paying practice.

WEIGHT OF THE COWS.

The several cows were weighed on three consecutive days just preceding the beginning and close of each period, and the average of each of these several weighings are given in Table No. 15:

Table 15. *Showing the Weight of the Cows at the Beginning and Close of Each Period.*

	PERIOD I.		PERIOD II.		PERIOD III.	
	Beginning.	Close.	Beginning.	Close.	Beginning.	Close.
Dollie	733.3	760.6	736.8	723.5	735.8	753.3
Jessie	871.3	900	908	918.6	918.3	924.1
Rose	816.3	830.6	839.3	837.1	826.6	824.3
Emma	846.3	854.3	834	854.6	855.6	863.5
Queen	736.3	734.6	721	736.6	738.5	728
Governor Heifer	689.6		662.5	666.6	679.5	673.1

From this it will be seen that the cows fluctuated only slightly in weight from period to period, and experienced but littl echange throughout the experiment.

The changes which did occur, however, are, perhaps, worthy of note as being apparently associated with the changes in the temperature of the water drank. Dollie, Jessie and Rose began and closed the experiment on cold water while the other three cows began and closed on warm water. If we group the weights of these cows on the basis of warm and cold water we shall have the results indicated in Table No. 16:

Table 16. Showing the Fluctuation in the Weight of the Cows Associated with the Temperature of the Water Drank.

	COLD WATER.			
	Period.	Beginning-	Close.	Difference.
		Lbs.	Lbs.	Lbs.
Dollie	I	733.3	760.6	+27.3
Dollie	III	735.8	753.3	+17.5
Jessie	I	871.3	900	+28.7
Jessie	III	913.3	924.1	+10.8
Rose	I	816.3	830.6	+14.3
Rose	III	826.6	824.3	— 2.3
Queen	II	721.0	736.6	+15.6
Emma	II	834.0	854.6	+20.6
Gov. Heifer	II	662.5	666.6	+ 4.1
Total gain				+136.6
WARM WATER.				
Dollie	II	736.8	723.5	—13.3
Jessie	II	908.0	918.6	+10.6
Rose	II	839.3	837.1	— 2.2
Queen	I	736.3	734.6	— 1.7
Queen	III	738.5	728	—10.5
Emma	I	846.3	854.3	+ 8.0
Emma	III	855.6	863.5	+ 7.9
Gov. Heifer	I	689.6	662	—27.6
Gov. Heifer	III	679.5	673.1	— 6.4
Total loss				—35.2

From this it will be seen that, with one exception, the cows were heavier at the close of the cold water periods than at the beginning, while at the end of the warm water periods the cows were, as a rule, slightly lighter, there being but three exceptions; these were made by Jessie and Emma, the two cows which made the greatest absolute gains during the entire experiment, but in these cases the gains made on cold water were equal to or larger than those made on warm water.

To what are these differences in weight to be attributed? It has been shown that the cows drank more warm water than they did cold, even in the case of Gov. Heifer, which disliked the warm water. This being true the cows which were put on cold water preparatory to the cold water period, after having been taking warm water, should be expected to drink less than the normal amount, and hence to enter upon the cold water period relatively light owing to a deficiency of water drank, but before the close of the period they would be forced, by the demands of the system, to increase the amount of cold water drank, and hence should be expected to leave the period with more water in their bodies than they entered it, and consequently somewhat heavier, but not, on this account, by an actual gain in tissues. But in case the cows are changed from cold water onto warm they should be expected to take into the system an abnormally large quantity of water at the start and hence to enter upon the warm water period, to this extent, relatively heavy, and, as this abnormally large consumption of water could not be expected to be maintained throughout the period, they should come sooner or later to drink less and hence lose in weight on this account, so far as amount of water in the system is concerned. This suggestion, as a possible partial explanation of the fluctuations in weight, cannot be tested very rigidly by the actual amounts of water drank on the days under consideration, because it was during a portion of these that the cows were experimented with as to their preferences for warm or cold water. The figures do show, as a matter of fact, that the cows were taking an average per head of 4.3 lbs. more water at the close of the cold water periods than on the preliminary days before them, while at the close of the warm water periods an average per cow of 6 lbs. less were taken than were drank on the preliminary days before these periods. But the weighings indicate that gains were made, amounting, in the aggregate, to 136.6 lbs. on cold water while the losses were 35.2 lbs. on warm water, amounts too large to be fully met by the differences in the quantity of water drank. Nor is this all. The fact that the cows on the five days closing the cold water periods, were taking, in the aggregate per head, nearly five pounds more water daily while there was no appreciable difference in the amounts drank daily at the beginning and close of the warm water periods, suggests, even more strongly, that some other explanation is to be sought for these fluctuations in weight.

The facts are, the cows on warm water ate more and drank more and yet lost in weight while the cows on cold water ate less and drank less, but gained in weight.

SUMMARY.

On the night of January 21, 1889, six cows were placed in stanchions side by side in two groups of three each, upon a daily ration of five pounds of bran mixed with two pounds of ground oats and six pounds of hay, together with what dry cut corn fodder they would eat up clean, and this ration was not changed until after the close of the experiment, March 25. During this time the cows were fed twice and watered once daily; they were allowed the freedom of the barnyard during the middle of each pleasant day, and in every way received similar treatment, except that when one group of cows was getting water at 32° F. the other took it at 70° F. The time of the experiment was divided into three periods of 16 days each, having intervals between them. At the close of the first and second periods the temperatures of the water were reversed for each of the cows in order to eliminate, so far as might be, the individual differences of the two groups.

In plan this experiment contemplated, as its chief object, ascertaining whether it is true, as many farmers believe, that warm water, for milch cows, produces a measurable increase in the yield of milk over that of cold water, and if so, whether this increase affects the volume simply or the weight of the solids contained to an extent which would make it remunerative, in general practice, to warm the water for cows.

The discussion of the results obtained has shown for these six cows, while under experiment, that:

1st. While on warm water they gave on the average 1.002 lbs. of milk per cow per day more than while on cold water, or 6.23 per cent. of the general average daily yield of 16.06 lbs.

2nd. They drank on the average, daily, while on cold water 63 lbs., but while on warm 73 lbs., or 10 lbs. per cow more.

3rd. They ate more while on warm water than while on cold, and at the rate of .74 lbs. of corn fodder per cow per day.

4th. An increase in the amount of water drank was coincident with an increase in the quantity of milk given and this was true irrespective of whether the water was warm or cold, an increase of 10 lbs. in every 100 lbs. of water drank being accompanied by an increase of 1 lb. in every 100 lbs. of milk given, nearly.

5th. They consumed solid food, while on warm water, at the rate of 1.44 lbs. for each pound of milk produced, and while on cold water at the rate of 1.54 lbs. for each pound of milk given.

6th. An increase in the amount of water drank, when the temperature of the water remained the same, was associated with an increase in the amount of water in the milk without a notable increase in the total solids contained.

7th. An increase in the temperature of the water drank rather than an increase in the quantity of it, was associated with an increase in the total amount of solids produced.

8th. There was a daily fluctuation in the percentage of water in the milk associated with a fluctuation in the amount of water drank.

9th. Five cows manifested a strong preference for water at 70° over that at 32°, but one of the cows showed an even stronger liking for the iced water.

10th. With but one exception, the cows, while they ate less and drank less during the cold water periods, weighed more at their close, and, with but three exceptions, they weighed less at the close of the warm water periods.

11th. With butter at $.20 per pound, skimmed milk at $.25 per cwt., corn fodder at $5.00 per ton, and the cost of warming water for forty cows 120 days at $15, the results obtained from the cows on the experiment indicate that a net gain of $21.36 would be realized on a herd of forty cows averaging sixteen pounds of milk per cow per day, and at least $10.00 on a herd of twenty, and $5 on a herd of ten cows. Counting corn fodder at $10 per ton, the net gain on a herd of forty cows would still be $12.48.

SOIL PHYSICS.

F. H. KING.

INTRUDUCTION.

It has long been appreciated, as a matter of the greatest economic moment, that farmers should know the actual and comparative values of all food-stuffs available for the maintenance and growth of domestic animals; that they should know specifically how to combine these so as to insure the largest possible returns for the food and labor expended; that they should know what food-stuffs are fairly equivalents and may be substituted one for another, and to these and many other allied ends large amounts of time, energy and money have been expended, but as these investigations have been chiefly conducted in Europe, under climatic and other conditions very different from those which exist in the United States, the results obtained are not specifically applicable here, and hence it is that these older lines of investigation are now being paralleled in this country with valuable results. The case stands similarly in regard to plant husbandry, but with this important exception: Plants being fixed in position and without the power of controlling their own temperatures, as animals do, are vastly more influenced by differences of soil and climate, so that the conclusions which have been reached, through studies in Europe, are much less likely to be specifically applicable in this country and hence, even were it true that all fundamental problems of tillage had been solved for Europe, their specific adaptation to our soils and climate would still require further study.

A large part of the scientific study which has been devoted to agriculture has been pursued from the standpoint of chemistry, and yet an industry nearly world-wide in its distribution, and so complex, as this confessedly is, manifestly demands approach from all possible sides, and it is in recognition of this fact that the director of this Station has taken the initial step, in this country, of having a chair of agricultural physics established here.

The work in soil physics, which has been commenced. relates, among other questions, specifically to the following:

1. To what depth below the surface is the water contained in the soil drawn upon by plants.

2. What is the amount of water the available depth of soil is capable of storing.

3. How much of the water stored in our soils different kinds of cultivated plants can use and yield average crops.

4. What is the amount of water a given soil must contain at the beginning of the growing season, supplemented by our average summer rainfall, to give an average yield.

5. When the amount of stored water in the spring is above or below that best suited to plant growth, what distribution of crops and what sort of tillage will yield the largest returns.

6. What volume of air various soils should contain to give the largest yields with different varieties of cultivated plants.

7. Do our present methods of tillage impart the desired porosity to soils.

8. Influence of different methods of tillage on soil temperatures.

9. Influence of our various methods of tillage on the rate of evaporation.

10. Whether one variety of corn, for example, requires more water than another to produce a pound of dry matter.

The aim in approaching these questions has been to make each case definitely a field study with soils undisturbed, except by the operations of tillage, using laboratory methods only as checks on field work and as suggestive of lines of procedure.

I. SOIL WATER.

1. AMOUNT OF WATER CONSUMED BY PLANTS.

Hellriegel found by experiments conducted in Prussia, that the amounts of water drawn from the soil and given to the air, by various plants under good conditions of growth, for each pound of dry matter produced by the crop in coming to maturity, were as stated in Table No. 1.

Table 1. *Number of Pounds of Water Transpired by Plants in Producing One Pound of Dry Matter.*

	Water.	Dry matter.		Water.	Dry matter.
	Lbs.	*Lbs.*		*Lbs.*	*Lbs.*
Barley	310	1	Horse-beans.....	282	1
Summer Rye......	353	1	Peas	273	1
Oats	376	1	Red Clover.......	310	1
Summer Wheat ...	338	1	Buckwheat.......	363	1

This, it will be seen, is at an average rate of more than 325 tons of water, for each ton of dry matter produced, withdrawn from the soil by the roots of the plants named in the table, when growing under the climatic conditions of Prussia and, if these results are correct, this is the amount of water required of the soil there, during the growing season, over and above that which is lost by drainage and evaporation from the ground.

The amount of water required for a ton of dry matter in Wisconsin has yet to be determined, but if we take the average of Hellriegel's results, given in the table, as applying to corn on the Experimental Farm, and 8,349* pounds as the average yield of dry matter per acre, the amount of water required is 62.2 pounds per sq. ft. of surface, or nearly 12 inches of rainfall. This is more than one-third the amount received during the entire year, and lacking but three inches of the mean rainfall which occurs during the months of May, June, July and August, that being 15 inches. It should be borne in mind, in this connection, that a large amount of water, especially in the early portions of the growing season, is lost by evaporation from the surface of the ground, not contributing to the growth of vegetation. The evaporation is also very rapid on the hot, clear days which follow heavy showers and may equal 7.15 lbs. from 4.91 sq. ft. of wet soil surface in 24 hours, or an amount which is equivalent to .28 inches of rainfall, this having occurred July 3 the past summer in an open field on the Experimental Farm. Then, again, not an inconsiderable amount of the moisture deposited upon our state in the form of rain and snow must be lost by evaporation during the eight months from September to April inclusive, when there is very little water used by vegetation. To these demands upon our annual rainfall must also be added the waters taken up and borne out of the state by the rivers which flow across our boundaries.

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* Fifth Annual Report Wis. Exp. Station, page 9.

2. NEED OF MORE DEFINITE KNOWLEDGE.

Since soils may contain either too much or too little moisture, for the best results in plant growth, it is evident that before methods of tillage, intended either to diminish or conserve the amount of water contained in the soil at any time, can be intelligently applied, many very fundamental facts and principles need to be better understood.

Just as in stock feeding it is important to know how many pounds of this or that combination of food-stuffs are required to produce a pound of mutton, pork or beef, so in plant feeding it is equally important to know how many pounds of water on this or that kind of soil are required to produce a pound of clover, corn, oats or potatoes.

More knowledge is needed as to the storage capacity for water of our soils in their natural conditions and positions; as to the per cent. of this water available for different crops in the production of good yields; as to the depth below the surface different plants can utilize soil-water; and as to the best methods of reducing the amount of soil-water when the soil contains too much, and of conserving it when the stock is below the average needed.

If we knew very definitely the amount of water our different varieties of soil should contain at the beginning of the growing season, when supplemented by the mean summer rainfall, to bring good crop yields, it would be a simple matter for any farmer to determine whether the water present in his soils was above or below the amount needed, and thus obtain a much better basis for judgment as to how to distribute his crops on his land, as to what his yields were likely to be and whether methods of tillage intended to reduce or conserve the moisture already in the soil should be adopted.

3. POSITION AND ATTITUDE OF THE WATER-TABLE.

To study the foregoing and allied questions from the experimental side it seemed important to know at the outset the distance from the surface of the cultivated fields and experimental plats to permanent water in the ground at the University Farm, and whether or not this water was drawn upon, especially during dry seasons, by the crops growing upon the land. The investigation was begun in August, 1888, and has been continued since when time permitted.

With the aid of an eight-inch post auger, provided with an extension handle, four lines of wells have been bored, three of them constituting north and south parallel series, and the other crossing these at a right angle. After the wells had been dug, five-inch unglazed drainage tile were placed in them to prevent caving. After taking the levels of the several wells and of the water in them, it was found, as shown in Figs. 1, 2 and 3, that the water stands everywhere in the ground above the level of the water in the lake, and that the level of the water-table rises where the ground rises and falls where it falls, but not in such a manner as to make the two surfaces parallel. In Fig. 1, for example, at a distance of 130 feet back from the lake shore the water in the ground stands about two feet above the lake level, but at the farther end of this line the difference of level is nearly ten feet. Nor is this attitude of the water-table a peculiarity alone of the immediate location under consideration, for a study in other places shows that similar conditions exist elsewhere. Even on Picnic Point, a long narrow peninsula only a few hundred feet broad extending out into Lake Mendota, the water-table is related to the surface as shown in Fig. 4, the water standing in the

Fig. 1.

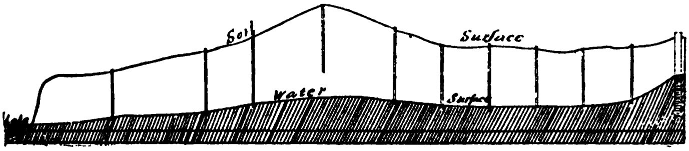


Fig. 2.

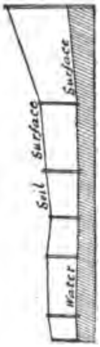
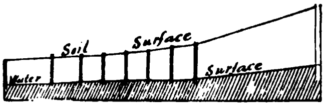


Fig. 3.



Figs. 1, 2 and 3, showing the relations of the water-table to the surface of the ground on the Experimental Farm. Figs. 1 and 3 represent north and south profiles and Fig. 2, one extending across the other two. The vertical parallel lines represent wells. Vertical scale,— 1 in. = 40 ft.; horizontal scale,— 1 in. = about 380 ft.

Fig. 4.

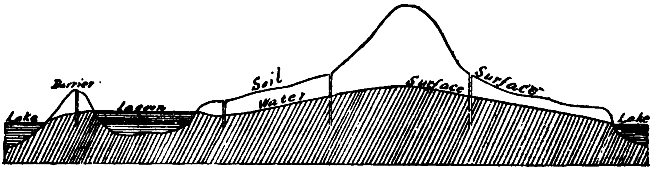


Fig. 4, showing the relation of the water-table to the surface on Picnic Point. Vertical scale, for the water-table 1 in. = 4 ft., for the surface, 1 in. = 8 ft.

center more than six inches above the level of the water in the lake. That this attitude of the water-table is not due to simple capillary action, in this case, is proven by the fact that water was not reached in the two central wells until a stratum of green sand, two feet below the level of the lake, had been entered; this being reached the water rose slowly until it stood six inches above the lake level.

4. FLUCTUATIONS IN THE LEVEL OF THE WATER-TABLE.

To ascertain, if possible, whether vegetation is able to avail itself, through capillary action, of the permanent ground-water and thus tide over seasons of drought, like those just past, the variations in the level of the water in the ground have been measured by means of an instrument constructed for the purpose, which is sufficiently sensitive to allow changes of level less than one-hundredth of an inch to be detected. More than 6,000 measurements of the level of the water in the wells of the four series have been made during the year, and as the water in these wells lies at different distances below the surface, some of the wells being below corn, others below oats, meadow, pasture, or woods, while others still stand in ground which bore no crop, the surface being simply tilled to prevent the growth of weeds, it was hoped that in case the permanent water in the ground was drawn upon by vegetation to any notable extent the fact would be revealed by differences in the fluctuations of the water level in the several wells.

The fluctuations observed have been surprisingly marked, and so varied as to indicate that several causes must be operating conjointly to produce them, but at this stage of the investigation it is evident that a longer series of observations and a more critical analysis of them than is now possible are required for a solution of the problems involved. Among the facts which the present study has developed are these:

1. There are, from May to October, daily fluctuations of the water level in the ground, the water either rising during the night or falling less than it did during the day.

2. There are fluctuations extending over several days, during one portion of which the water falls at a rate faster than the average, while during the remainder of the time it either makes a positive rise or else falls at a rate below the average.

3. The diurnal fluctuations are very unequal in magnitude, varying in different wells from less than one or two hundredths of an inch to an inch and seven-tenths.

4. The longer interval fluctuations are not exactly synchronous, there being a lagging, with some wells, of more than 24 hours.

5. Corn is able to draw upon the permanent water in the ground when it lies at a depth at least as great as seven and one-half feet, in the case of a subsoil of rather coarse sand.

6. Corn may reduce the per cent. of water in a subsoil of sand to 7 per cent. of the dry soil at a depth of 40 inches below the surface, and when the water-table is but 42 inches still lower.

5. THE CAPACITY OF SOIL TO STORE WATER.

The fact, universally observed, that during seasons of drought vegetation suffers from lack of moisture, even when the water-table lies within five feet of the surface, proves conclusively that the rate at which capillary action can carry water toward the surface is not great enough, at all times, to meet the demands of cultivated crops, and this being true, it is important to know, first, the capacity of the upper five to seven feet of soil to store water, and second, the per cent. of this stored water different varieties of cultivated plants can profitably use, for these facts stand in the same relation to plant feeding that a knowledge of the amount of hay and grain stored in the barn does to stock feeding.

To ascertain how great the storage capacity of undisturbed soil may be, five tin cylinders, each one foot in length and six inches in diameter, were filled with soil, in its natural condition, by forcing them full length into the ground. When the first cylinder had been forced a few inches into the ground, the soil around was removed down to a level with the bottom of the tube, when it was again forced farther into the soil. This process was repeated with each cylinder until the five together contained a vertical column of undisturbed soil five feet in length. The lower end of each cylinder was then provided with a perforated tin cover, and, after being weighed, was immersed in water to within a short distance of the top. The tank in which the soil stood was covered so as to prevent evaporation, and in this condition the cylinders remained five days to become filled with water. The water was then withdrawn from the tank, and the soils allowed to drain four days in a saturated atmosphere. They were then weighed, after which they were dried and weighed again with the results indicated in Table No. 2. From this table it will be seen that the upper five feet of soil are able to store an amount of water which would cover the surface 21.24 inches deep:

Table 2. Showing the Storage Capacity of Undisturbed Soil for Water.

Depth of Samples.	Weight after saturation.	Weight dry.	Water contained.	Water expressed in in.	Character of soil.	Per ct. of water.
	Lbs.	*Lbs.*	*Lbs.*	*Inches.*		
1 to 12 inches....	19.96	15.09	4.87	4.59	Marly loam..........	32.2
12 to 24 inches............	23.46	18.94	4.52	4.26	Reddish clay..... ...	23.8
24 to 36 inches............	23.52	18.89	4.63	4.37	Reddish clay........	24.5
36 to 48 inches............	24.45	19.94	4.51	4.25	Clay with sand.......	22.6
48 to 60 Inches............	26.92	22.92	4.00	3.77	Very fine sand........	17.5
Sums........			22.53	21.24		

This amount of water represents three-fifths of the total average annual rainfall of this locality, but probably not much more than 12 inches of this water is available for crops when they give an average yield.

These samples of soil were dried in the cylinders in which they were taken by standing them upon a steam radiator until they were nearly dry, after which they were transferred to the top of the steam boiler used in heating the building. The whole time consumed in drying was 62 days, during 40 of which they stood upon a steam radiator, and during this time they were weighed daily. The rate of drying was most rapid in the surface foot, the last foot standing second. By expressing the loss of water during 10 days as a per cent. of that contained in the soil at the beginning of each 10 days we have the results given in Table No. 3.

Table 3. Showing the Rate of Evaporation in Soils in their Natural Condition, when Dried Artificially.

		1st. foot.	2nd foot.	3rd foot.	4th foot.	5th foot.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Per cent. of water contained in the soil evaporated from it during the.............	1st ten days.. ...	69.30	50.63	42.95	45.85	60.84
	2nd ten days	54.87	37.35	36.75	38.84	48.74
	3rd ten days......	60.13	38.01	49.41	39.43	51.63
	4th ten days......	85.25	57.50	76.56	60.00	58.42

After the soil in the cylinders had been thoroughly dried and weighed, they were again returned to the water and allowed once more to become thoroughly filled, the object being to determine the capacity of these soils for water when lying below the water table. At this stage the cylinders, when removed from the water, were placed at once upon trays before the water had time to drain away, only the water adhering to the sides of the tubes being wiped off before weighing. The results obtained are given in Table No. 4.

Table 4. Showing the Capacity of Undisturbed Soil for Water When Lying Below the Water-table.

Depth of sample.	Weight when full of water.	Weight dry.	Weight of water.	Water expressed in inches.	Per cent. of water.
	Lbs.	*Lbs.*	*Lbs.*	*Inches.*	*Inches.*
1 to 12 inches.......	21.33	15.09	6.24	5.88	41.3
12 to 24 inches......	24.27	18.94	5.33	5.03	28.1
24 to 36 inches......	24.27	18.89	5.38	5.07	28.4
36 to 48 inches......	24.89	19.94	4.95	4.67	24.8
48 to 60 inches......	26.91	22.92	3.99	3.76	17.4
Sums...... ...	....	....	25.89	24.41	....

This table shows that the soil under experiment, when thoroughly filled with water, as might be the case in early spring after a series of heavy rains, may contain an amount of water which would give a depth of 24.41 inches to each square foot of surface, or more than two-thirds of our mean annual rainfall. It should be noted, however, that the lower two feet of soil in the column possessed pores so small that capillary action was capable of maintaining them practically full of water, so that the storage capacity here is scarcely greater than that indicated in Table No. 2. The increased storage capacity in the upper three feet, shown by the last table, can of course only be of service temporarily by preventing the water from being lost quickly by surface drainage; but this is a matter of considerable moment, because the underground drainage must usually be much slower than that of the surface, and hence the water-table is maintained at a higher level, thus holding permanent water in the ground nearer to the roots of plants, making it unnecessary for roots to be sent so deeply into the ground, or for capillary action to lift the water so high as would otherwise be the case. The relative volumes of soil, water and air, in the samples studied, are shown in Fig. 5. From this figure it will be seen that, when the soil under consideration was saturated with water, the spaces occupied by air diminished downward and almost disappeared at five feet from the surface. It will also be evident that saturated soils really contain large volumes of water.

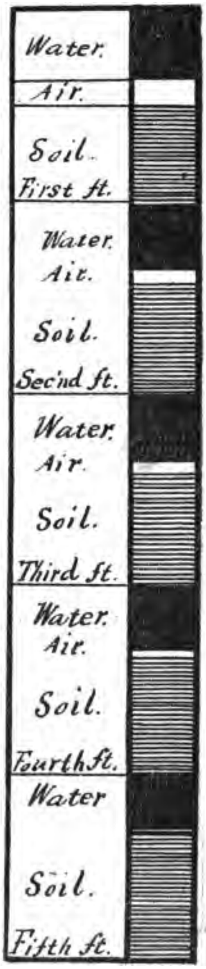


Fig. 5. Showing the relative volumes of water, air and soil in the upper five feet of cultivated ground.

6. RATE AND EXTENT OF CAPILLARY MOVEMENT OF WATER IN SOIL IN ITS NATURAL CONDITION.

It appears to be generally conceded that capillary action is an important factor in lifting the ground-water toward or to the surface, where plants can avail themselves of it, and of the minerals it may hold in solution. How rapid this movement may be in soils of different kinds and depths, as they exist undisturbed except by the processes of tillage, is a question having many important practical bearings; and yet our specific and positive knowledge on this subject is very limited indeed. The fact that vegetation, during seasons of drought, suffers for lack of moisture, even where permanent water exists in the ground within a few feet of the surface, is conclusive evidence that the normal rate of capillary movement is not very great. The fact that many trees growing near drains thrust their roots through the joints of the tile, and then break them up into vast bundles of slender fibers, proves that there is a real struggle for water in the natural soil, and that plants must, at times, send their roots out for water rather than wait for capillary action to bring it to them.

How incapable capillary action is to supply water to soil as fast as plants may withdraw it is shown by the following observations: On May 13, while corn ground recently planted contained 23.33 lbs. of water to the 100 lbs. of dry soil, in the surface six inches, clover, growing not two rods distant in the same kind of soil, had drank the water so much faster than capillary action could bring it that there remained but 8.59 lbs. to the 100 lbs. of dry soil. The figures below give the condition of these soils at this time to a depth of 24 inches:

Depth of soil.	Corn ground.	Clover ground.
0 to 6 inches deep	23.33 per cent. of water	8.59 per cent. of water.
12 to 18 inches deep.... .	19.13 per cent. of water	14.79 per cent. of water.
18 to 24 inches deep.....	16.85 per cent. of water	13.75 per cent. of water.

These facts illustrate in a very forcible manner the great power vegetation has of withdrawing water from the soil, and how naked tillage conserves it, while at the same time they furnish the strongest possible argument against allowing even a single weed to grow in a field where other crops are expected.

To study the rate at which water may rise in different kinds of soil in their natural conditions, the cylinders described on page 196 were placed with their feet resting in water one inch deep after the soil had been dried, and the rate at which the water rose in them noted by daily weighings. Although the cylinders were only 12 inches long and the surface of the soil but 11 inches above the water and surrounded by an atmosphere saturated with moisture, it was five days before the fine sandy soil appeared damp at the surface, six days before the first and fourth feet showed moisture, 18 days before the third, and 22 days before the second foot looked damp at the surface. The rate at which the several samples of soil became saturated with water is shown in Table No. 5:

Table 5. Showing the per cent. of Moisture in the Soil, and the per cent. of Gain by Capillary Action during Intervals of Three Days.

DATE.	1ST FOOT.		2ND FOOT.		3RD FOOT.		4TH FOOT.		5TH FOOT.	
	Water in soil.	Gain.	Water in soil.	Gain.	Water in soil.	Gain.	Water in soil.	Gain.	Water in soil.	Gain.
	per ct.	*per ct.*	*per ct.*	*per ct.*	*per ct.*	*per ct.*	*per ct.*	*per ct.*	*per ct.*	*per ct.*
Feb. 17...	0	0	0	0	0	0	0	0	0	0
Feb. 20...	....	18.95	....	14.86	....	12.03	....	15.18	....	10.65
Feb. 23...	18.95	3.34	14.86	2.26	12.03	2.42	15.18	3.53	10.65	2.51
Feb. 26...	22.29	2.26	17.12	1.06	14.45	1.62	18.71	1.68	13.16	1.84
March 1..	24.55	1.73	18.18	.82	16.07	1.33	20.39	.50	15.00	.52
March 4..	26.29	1.25	19.00	.61	17.41	1.21	20.89	.23	15.52	.14
March 7..	27.55	.57	19.61	.48	18.62	1.04	21.12	.17	15.66	.05
March 10..	28.11	.16	20.10	.33	19.66	.72	21.29	.01	15.71	.01
March 13..	28.28	.09	20.43	.26	20.39	.50	21.30	.03	15.72	.02
Saturated	32.2	... ...	23.8	....	24.5	....	22.6	....	17.5	....

It will be seen from these figures that twenty-four days were not sufficient time for capillary action to completely saturate cylinders of undisturbed soil twelve inches long standing one inch in water; indeed, they had not reached the point of saturation at the end of thirty-four days.

The slow rate of movement of water in natural soil under natural conditions is also forcibly illustrated by the following facts:

The per cent. of water in soil on which corn had been grown was determined down to a depth of three feet on October 23, and again on December 13, with the results given below, standing water in the ground at the time being 7.5 feet below the surface:

Surface Foot.

October 23, water in the soil	10.22 per cent.
December 13, water in the soil	21.26 per cent.
Gain in fifty-one days	11.04 per cent.

Second Foot.

October 23, water in the soil	10.91 per cent.
December 13, water in the soil	12.76 per cent.
Gain in fifty-one days	1.85 per cent.

Third Foot.

October 23, water in the soil	8.61 per cent.
December 13, water in the soil	9.17 per cent.
Gain in fifty-one days	.56 per cent.

Rain had fallen during the interval to the amount of 2.18 inches, and as the surface foot can hold but 4.59 inches of rain, as shown in Table No. 3, this being 32.2 per cent. of the dry soil, the moisture in the surface foot should have been increased to about 26.22 per cent. The soil did contain 21.26 per cent., which leaves nearly 5 per cent. to be accounted for by capillary action downward and by evaporation. Owing to the naked, dry condition of the soil, the evaporation must have been quite small during the time, and as the second foot only gained 1.85 per cent. of moisture, the 5 per cent. surplus appears quite large enough to account for this gain and the evaporation. If this is true, the third foot, which was only four and one half feet from permanent water, only gained from below in 51 days about .025 lb. of water. Here again the facts indicate in an emphatic manner that during ordinary seasons we need to do what we can to save not only the moisture already in the soil, but also that which falls as rain from time to time during the summer; they point, too, with equal emphasis, to the necessity of draining cultivated soils where the water in them naturally lies too near the surface, rather than depend upon capillary action and evaporation to do the work.

7. RATE OF CAPILLARY MOVEMENT IN FINE SAND.

Under a considerable portion of the experimental farm there is a stratum of very fine sand, approaching quick sand in character, in which permanent water is found during ordinary seasons, but which, during dry seasons, is called upon to transfer by capillary action, to the soil above, water from the falling water-table, and it appeared desirable to know how rapidly this transfer might take place when different thicknesses of this sand had to be traversed by the capillary waters.

To study this question a galvanized iron cylinder, four feet long and one foot in diameter, was filled with the sand and placed in front of a ventilator, in the laboratory, where a current of air, measured by an air meter, could be directed across its top. A layer of gravel covered with a towel and coarse sand, to secure a permanent water chamber, was placed in the bottom of the cylinder, which was then filled by stirring the sand in the water which had been placed in the cylinder to the depth of about one foot. By this means all air was removed from the soil, and the sand deposited as separate grains in the water and completely saturated with it. Provision was made for introducing water at the bottom, and of maintaining its height in the soil at any desired level. The water was allowed to enter the cylinder as rapidly as it was removed by evaporation, and the quantity so entering made known by a weighing device.

The water level was first maintained at the surface of the ground, then in succession at one foot, two feet, three feet, and four feet below. The results are given in Table No. 6:

Table 6. Showing rate of Capillary Flow of Water in fine Sand.

No. of days.	Level of water.	Mean capillary movement.	Revolutions of the anemometer.	Absolute humidity.	Relative humidity.	Mean A. M. temperature of air.
8	At surface.	1.78 lbs.	1419*	1.812 gr.	38	53
10.5	1 foot below.	1.96 lbs.	1432	3.065 gr.	50.5	60.4
11	2 feet below.	1.71 lbs.	1507	2.955 gr.	45	62
10	3 feet below.	1.01 lbs.	2248	3.178 gr.	47	63.9
24	4 feet below.	.75 lbs.	2684	3.477 gr.	49.5	64.5

* Mean number of revolutions of the anemometer during the evaporation of 1-1000 of a pound of water.

From this table it will be seen that the capillary movement through the fine sand averaged more than one pound per day in a cylinder one foot in diameter, which is less than a square foot in cross section. The mean daily capillary movement for a cylinder whose area is one square foot in cross section, computed from the results in the table are as given below.

Water level at surface.	1 foot below surface.	2 feet below surface.	3 feet below surface.	4 feet below surface.
2.16 lbs.	2.37 lbs.	2.07 lbs.	1.23 lbs.	.91 lbs.

During the whole time this experiment was in progress the sand remained wet at the surface, so that it appears certain that the rate of capillary movement in this sand, under the conditions of the experiment, might have been greater than the figures indicate had the rate of evaporation been greater.

8. INFLUENCE OF STIRRING THE SOIL ON THE RATE OF EVAPORATION.

It is maintained by many farmers that stirring the soil tends to diminish the rate of evaporation, and hence that frequent or constant cultivation of the ground, especially in a dry time, is a paying practice. After the experiment, just described, had been completed this question was studied, with the same aparatus and the fine sand.

The first treatment was to take a pocket knife and with the sharp edge of the blade cut the surface of the sand to the depth of about two inches into small squares about an inch on a side, the blade of the knife being held during the operation in a vertical plane. As an immediate result of this treatment the rate of evaporation increased, during the following ten days, from .75 pounds daily, as given in Table No. 5, to 1.38 pounds per day, for the wind velocity, air temperature and absolute humidity remained very nearly as before.

At this stage about two inches of the surface soil were removed from the cylinder, and immediately returned to it, but in a loose condition. The rate of evaporation diminished at once, and during the next ten days averaged a little less than .5 lbs. daily, while other conditions remained essentially the same as before. The water level, during these two experiments, was maintained at four feet below the surface of the soil, so that these results are directly comparable with those given in the last line of Table No. 6.

The increased rate of evaporation during the first experiment was due chiefly, in my opinion, to the fact that the surface exposed to the air currents was considerably increased without destroying the good soil connection with the water supply below. There was, however, one other condition which may have contributed to increase the difference in the rate of evaporation in the first of the two experiments, and the last one given under the preceding topic. At the end of that experiment it was found that a continuous crust of mineral deposit had covered the surface of the sand to a depth apparently between .02 and .03 inches and this had been removed, for chemical analysis, before the beginning of these experiments.

Whether this incrustation tended to increase or diminish the rate of evaporation in these experiments cannot now be settled, though it appears possible, if not probable, that it diminished it.

The great difference between the rates of evaporation in these two experiments must have been due very largely to the difference in the two conditions of the surface of the sand, and furnishes a strong confirmation of the view that surface treatment of cultivated lands may exert a marked influence upon the rate of evaporation of water from it, and upon the rate at which the capillary supply of water may be delivered at the surface.

These experiments must be repeated with different kinds of soil, and especially with the surface soils, before general conclusions can be based upon them, but they suggest the following:

1. A tool like the disc harrow, or like the curved toothed harrows, which cut narrow and comparatively deep grooves in the soil, leaving undisturbed ridges between them, tend to dry the ground rapidly and deeply.

2. Tools like the plow, and some forms of cultivators, which cut the whole surface of the ground, leaving a loose layer of soil on the top, tend to dry the loosened soil while the loss of moisture from below by capillary action and evaporation is diminished.

3. Deep plowing in the spring, especially if the soil is heavy, and if coarse material is turned under would tend, unless prevented by early heavy rains, to produce a deficiency of moisture for shallow rooted plants, and for deep rooted plants during the early part of the season, by partially cutting off the water supply at a depth below the roots.

4. Shallow plowing or surface stirring would tend to diminish surface evaporation, and at the same time allow capillary action to lift water from below to the roots of young and shallow rooted plants.

5. Fall plowing and early spring treatment with tools like the disc harrow would tend to draw the water to the surface with the minerals held in solution, and thus concentrate the fertility at the surface for later use, thus preventing so much being lost by under-drainage.

MISCELLANEOUS CHEMICAL WORK.

PRICKLY COMFREY vs. RED CLOVER.

F. W. WOLL.

To determine the quantities of food material furnished by the two forage plants, red clover and prickly comfrey, under similar conditions, two equal plats were staked off at the University Farm during the spring of 1888. The size of the plats was 1,632 square feet. The comfrey was planted in the spring of 1887, in rows four feet apart, and a plant every eighteen inches; it was top-dressed heavily once with rotten stable manure, and the manure was worked into the ground with a cultivator. The clover was sown in the spring of 1887, on well prepared land; no manure applied in 1888. The comfrey plants were cut the first time when beginning to blossom; second and following crops were cut when it began to throw up seed stems. Both comfrey and clover were cut with a scythe. The first crop of clover was cut when in full bloom; like the other cuttings it was cut by hand very close to the ground, so that a second crop had a good opportunity to grow; the second crop was cut when blossoms began to appear. The comfrey was cut four times during the season, and the clover three times. The clover did not grow any after the third crop had been cut, October 6; the fourth crop of comfrey was very insignificant, and the larger part of it would have been lost, if it had been cut with a mower, as it lay very close to the ground.

The various cuttings gave the following number of pounds of fodder:

Yield of Red Clover and Prickly Comfrey.

No. of Crop.	RED CLOVER.		COMFREY.	
	Date of cutting.	Weight of fodder.	Date of cutting.	Weight of fodder.
		Lbs.		*Lbs.*
1st crop	May 29	1097.0	May 29	866.50
2nd crop	July 16	600.0	July 3	693.00
3rd crop	Sept. 1	270.5	Aug. 25	759.75
4th crop			Oct. 6	204.00
Total		1967.5		2523.25

The plats from which the crops were cut contained 1,632 square feet. Calculating what would have been produced on an acre of land, in every way similar to the plats, we get the following results:

Calculated Produced from One Acre.

	Clover.	Comfrey.
	Lbs.	*Lbs.*
First crop	29220	23130
Second crop	16020	18490
Third crop	7221	20280
Fourth crop		5445
Total	52461	67345

It will be seen that the clover would have furnished more than 26 tons of green fodder to the acre, and the comfrey nearly 34 tons; 15 tons of clover to the acre may be considered a good yield; 26 tons, as we here calculated, would be a maximum yield. The crop was cut and gathered very carefully. The yield of prickly comfrey must be considered good when we remember that it was only second year's growth. Dr. Foster, of New York, who has grown the comfrey with remarkable success for a number of years, claims 50 tons to the acre, after five years' cultivation.*

The value of the prickly comfrey plant depends entirely on its qualities as a soiling crop; according to observations made at the N. Y. Experiment Station it is of no value for hay or ensilage.†

Contrary to the experience at the N. Y. Station, we find that our cows do not take well to it, when anything else is offered them. They have to be broken in to eating it. ‡

The yield per acre of the two forage crops cannot be taken as a direct measure of their value as fodders, as they are not equally valuable pound for pound. In our investigations last year samples were taken of every cutting of the clover and of the comfrey, and these samples were submitted to chemical analysis. From the data thus obtained we are able to judge about the quantity of food materials furnished in the different cuttings in case of both crops.

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*N. Y. Exp. Station Report, 1887, p. 422.

†Ibid., 1888, p. 333.

‡See 5th Annual Report Wis. Ag. Exp. Station, 1888, p. 139.

Percentage Composition of Samples of Clover and Comfrey.

	CLOVER.			COMFREY.			
	First crop.	Second crop.	Third crop.	First crop.	Second crop.	Third crop.	Fourth crop.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Dry matter........	8.22	22.48	27.49	8.30	11.33	8.27	14.38
Moisture...........	91.78	77.52	72.51	91.70	88.67	91.73	85.62
Dry matter contained —							
Ash	10.42	7.75	7.18	15.00	18.68	16.50	18.94
Ether extract....	4.06	3.00	3.84	2.51	1.47	3.73	2.49
Crude fiber......	22.18	24.83	23.90	13.42	21 91	14.28	10.44
Crude protein.,..	20.81	14.81	15.93	21.50	14.75	13.38	16.63
Sugar............	2.64	7.38	4.74	7.08	4.68	12.84	9.00
Starch, gums, etc	39.89	42.23	44.41	40.49	38.51	39.27	42.50
	100.00	100.00	100.00	100 00	100.00	100.00	100.00
Albuminoid N.....	2.48	2.15	2.47	2.99	2.08	2.02	2.42
Amide N..........	.85	.22	.08	.45	.29	.12	.24
Per cent. Amide N.	25.53	9.28	3.14	13.08	12.28	5.61	9.02

We shall not here discuss the above table; attention is only called to the large amount of water in the first cutting of both forage plants, and also of all cuttings of the prickly comfrey. Only 8.22 per cent. of the total weight of the first crop of clover was dry matter, all the rest was water. This is more water than is contained in ordinary skimmed milk. The highest percentage of dry matter in any of the cuttings of the prickly comfrey was 14.38 per cent., or one-seventh of the total weight of the fodder. In a preceding table were given the quantities of clover and comfrey calculated obtained in the different cuttings from an acre of land. We will combine these data with the ones given in the above table, and thus ascertain the number of pounds of the different nutriments supplied by red clover and prickly comfrey.

Nutriments Calculated Produced from One Acre of Land, in Pounds.

	RED CLOVER.				COMFREY.				
	First crop.	Second crop.	Third crop.	Total.	First crop.	Second crop.	Third crop.	Fourth crop.	Total.
Dry matter.....	2402.0	3599.0	1986.0	7987.0	1920.0	2095.0	1677.0	782.9	6474.9
Ash....	250.2	279.0	142.5	671.7	288.0	391.4	276.7	148.3	1102.4
Ether extract ..	97.5	108.0	76.2	281.7	48.1	30.8	62.6	19.5	161.0
Crude fiber.....	532.7	893.9	475.0	1901.6	257.6	459.1	239.4	81.7	1037.8
Crude protein..	499.9	533.2	316.2	1349.3	412.8	309.1	224.5	130.2	1076.6
Sugar...........	63.4	265.7	94.1	423.2	135.9	98.1	215.3	70.5	519.8
Starch,gums,etc	958.3	1519.2	882.0	3359.5	777.6	806.5	658.5	332.7	2575.3
Total... ..	2402.0	3599.0	1986.0	7987.0	1920.0	2095.0	1677.0	782.9	6474.9

The preceding table shows that the red clover yielded more dry matter and protein in three cuttings than did prickly comfrey in four, 23 and 25 per cent. more respectively. The prickly comfrey was in its second year's growth; it might have made a still more vigorous growth if it had been older established in the ground. This investigation will be continued next year, to ascertain the yield of comfrey during the third year.

There are, however, other points to be considered besides the actual yield of dry matter and important food elements from a given area; the cost of the clover seed and of the comfrey plants, of growing the crops and of gathering them, and their adaptability as cattle foods are equally important, and should not be lost sight of.

It would seem that the prickly comfrey, while yielding an enormous quantity of green fodder per acre when once established, cannot, all things being considered, compare in value as a cattle food with red clover, looking at both forage plants from the standpoint of the general farmer. For the dairymen, who are keeping a large number of cattle on a small area of land, it may prove, and undoubtedly has proved with some, a valuable adjunct to their list of soiling crops.

LOSSES IN HAY DUE TO WEATHERING.

F. G. SHORT.

From a mixed lot of fresh clover and timothy grass, four samples of two kilos each (about four and one-half pounds) were selected. The first sample was immediately dried and analyzed; the remaining three samples were spread out in the field on a piece of mosquito netting and covered with the same, so that they might remain exposed to the weather and yet not be blown away or lost. One sample was analyzed July 23, after the first rain, and the others at later dates, as shown in the table. The following table shows the dry matter and protein of the samples. As all were supposed to have contained equal amounts of dry matter and protein at the beginning of the trial, it is assumed that the differences between the amounts of the components in the last three samples and the first are due to weathering.

Table Showing the Loss of Nutritive Matter of Hay due to Weathering.

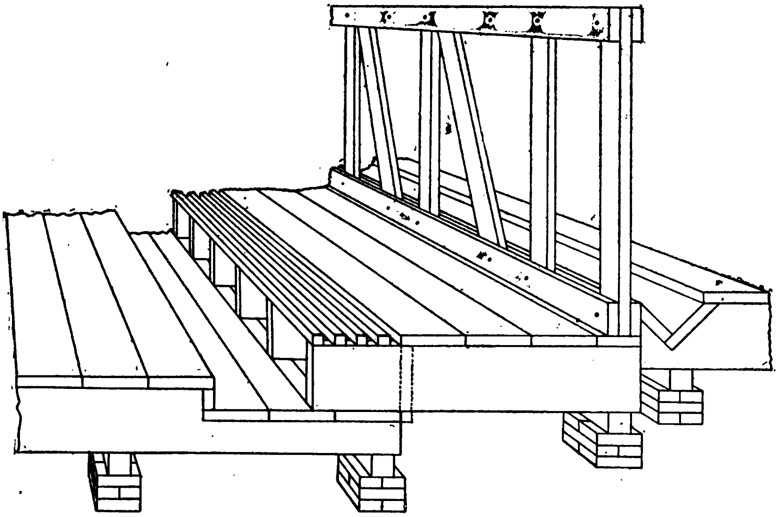
		Total dry matter in samples.	Total protein in samples.	Loss of dry matter.	Loss of protein.
		Grams.	*Grams.*	*Per cent.*	*Per cent.*
Sample 1	July 19	784.8	59.28	....	....
Sample 2	July 23	748.9	57.07	4.57	3.68
Sample 3	Aug. 1	748.5	56.82	4.61	4.10
Sample 4	Sept. 5	599.8	44.99	23.56	24.08

It will be observed that by leaving the hay out only four days after cutting, during which time there was a rain, there was a resultant loss of over four and a half per cent. of dry matter, and over three and a half of protein. By August 1 no further material change had occurred, but by September 5 nearly one-fourth of the dry matter and an equal proportion of protein had disappeared. As the parts lost were soluble, and as the palatability of the hay must have been greatly reduced, these figures do not, however, represent the actual diminution in value of the hay thus exposed.

STABLE FLOOR AND WATERING TROUGH FOR THE DAIRY STABLE.

L. H. ADAMS.

The stable floor, shown in the illustration, is essentially the same as the one now in use in the dairy stable at the Station Farm. The plan was obtained from C. L. Gabrielson, New Hampton, Iowa. After three years of experience we have found the floor very satisfactory, since cows standing on it keep very clean, even without bedding. The cows stand in a double row, facing out, on a raised platform, like that in the cut. The floor under their forefeet is made solid, of planks; that under their hindfeet is of 2x2 inch hard pine slats, four in number as shown in the illustration. The slats are covered on the upper face by a strip of band-iron two inches in width, fastened with countersunk screws. The cost of the iron is very small, and the strip prevents the slats from wearing round. They are



Cut Showing Floor and Watering Trough in Dairy Stable.

placed one and one-half inches apart; this width is found satisfactory in all respects. The floor under the cattle rests upon 2x10 joists, placed so that one comes directly under each cow, thus preventing the slats from springing. This makes a drop behind the cows of one foot. The manure drop extends 14 inches under the slats, and 18 inches back of them. The passage way back of the drop is raised six inches above it, and is wide enough for a wagon to pass between the cattle for collecting the manure.

With the kind of floor we have described under the cattle, it is not necessary that each cow should stand with her hind feet just on the edge of the raised floor, as they must on tight floors, if they are to be kept clean. Fifty-four inches from the stanchions to the edge of the drop is about the right length for the raised floor on which the cows stand.

The watering and feeding trough, shown in the cut, has also been found very satisfactory after five years' use. We first saw this at the stable of Mr. Wm. P. Phillips, Lake Mills, Wis. The trough is made by spiking a ten-inch to a twelve-inch plank, in the manner shown, breaking joints so that the whole is continuous and strong. The bottom of the trough should be level with the floor on which the cows stand. By giving it a fall of one inch in twenty feet, water let in at the upper end will pass slowly down affording all of the animals a drink without any inconvenience. Grain or meal is fed in the same trough. Before watering, if any litter is found in the trough, it is removed by passing a broom along it. Water is let into the upper end of the trough through an iron pipe from a covered tank outside the barn. Surplus water is drawn from the trough by pulling a plug at the lower end, allowing the waste to pass into a small brick cistern or cess-pool below. The feeding floor on a level with the top of the trough, is three and one-half feet wide, affording ample space for holding hay. This takes the place of a closed manger, and seems preferable, as the feed is easily placed before the cows, and everything can be kept clean.

COMPOSITION OF FEEDING STUFFS.

F. W. WOLL.

When the chemist speaks of the feeding stuffs used for the nutrition of farm animals, he employs certain technical terms, which at once convey to the reader familiar with them, a full understanding of the fodder as far as its chemical composition is concerned; to those unfamiliar with these terms, on the other hand, they are wholly unintelligible. In the following some brief explanations on this point will be given, in order to enable the reader to understand the discussions entered upon at other places in this report and elsewhere, concerning the chemical composition of feeding stuffs.

The fodders are made of I, *Water*, and II, *Dry Matter*.

I. *Water* is found in all feeding stuffs. It is present in by far the larger proportion in green and succulent fodders; out of 100 lbs of pasture grass, 80 lbs. are water; green clover and ensilage contain about the same quantity of water, while mangolds and turnips contain as much as 90 lbs. out of every hundred pounds of fodder. In the different kinds of hay, straw and grain, the quantity of water present is only from 10 to 12 per cent. Water is determined by heating the fodder prepared for analysis for several hours at 212° F.

II. *Dry Matter* is what is left behind when all water is driven off the fodder. It is composed of (1) *Mineral matter* or *ash*, this being the non-combustible part of the plant, and (2) *Organic matter*. The *ash* goes to make the bone of the animal and to supply material for maintenance of other parts of the animal body. *The organic matter*, being the part of the fodder which is destroyed by combustion, is composed of the following groups of nutritive elements, (a) *fat*, (b) *crude protein*, (c) *crude fiber* and (d) *nitrogen-free extract*.

a. *Fat* or "*Ether Extract*," includes what is dissolved out from the water-free substance with dry ether. Fat forms the main part of the extract; the other matters extracted are wax, chlorophyll (the green coloring matter in plants) and various other substances; the term "ether extract" has been used in the following, as it gives a truer name for the group, than does fat.

b. *Crude protein* signifies a large number of bodies characterized by the fact that they all contain the element nitrogen, which none of the other components of organic matter contain. Crude protein includes *albuminoids* and *amides. The albuminoids* are the substances which go to make up the flesh, ligaments, tendons, etc., of the animal body, hence they are often called *flesh-formers.* White of egg, lean meat, curd of milk and gluten are typical albuminoids. The albuminoids are either insoluble in water or, if soluble, coagulate, that is, rendered insoluble, by heat. In this they differ from the other group of nitrogenous organic bodies, *the amides.* These are all soluble in water. Asparagin, leucin, tyrosin are the amides present in plants in the largest quantities. The nutritive value of amides is probably somewhat lower than than that of the albuminoids, as they cannot fill all their functions. Their value in animal nutrition has not yet, however, been fully ascertained, the study of the subject having only been taken up in later years. Amides are present in considerable quantities in immature plants, root crops and ensilage. They are only in a transitory state in the living plant, being later converted into albuminoids and serving as agents for the transfer of protein from one part of the plant to another.

Both albuminoids and amides contain about 16 per cent. of nitrogen; this is true for the greater part of the former, approximately so for the latter. In the chemical analyses, total nitrogen and albuminoid nitrogen are determined, the total nitrogen multiplied by 6.25 ($= \frac{100}{16}$) equals crude protein, and albuminoid nitrogen multiplied by 6.25 equals albuminoids; the difference gives the amides.

The protein bodies are considered of the greatest importance for the nutrition of animals. They supply the material for building up the tissues of the body, and for maintaining these under the wear caused be the vital functions. If present in excess, they may by used for formation of fat in the animal body, or for production of heat. This, however, is not advantageous to the feeders, as the nitrogen-free nutritive elements will do the same work, and they may be procured at less expense.

c. *Crude fiber* or *crude cellulose* is the frame work of the plants, forming the walls of their cells. It is usually the least digestible part of the plants. It is determined in the laboratory by boiling the fodder successively with a weak acid and alkali, thus dissolving out all other parts of the fodder.

d. *Nitrogen-free extract* signifies what is left of the organic matter of the plant after deducting the preceding groups of elements. It cantains *starch*, *sugar*, *dextrine* and *gums*. Together with cellulose it forms the group of bodies called *carbhydrates*. They all contain the three elements, carbon, oxygen and hydrogen. A general name for carbhydrates is "*heat producers*," this, together with formation of fat, being their main office in animal nutrition. Nitrogen-free extract is determined by difference; total dry matter minus ash, fat, crude protein and crude fiber giving the percentage present.

In the following table will be found the chemical composition of our more common feeding stuffs. The figures given are averages of a smaller or larger number of analyses of each feed. The larger the number of analyses, the nearer the figures given will naturally come to the true averages. It is to be remembered, however, that, especially in the case of the coarse fodders, the chemical composition changes considerably with the maturity of the plant, the soil, the treatment of the soil, and the treatment which the fodder has received from the time of cultivation to when it is fed to the animals. The composition of a certain feeding stuff may therefore differ considerably from the average analysis. The right way to do, would be to give the variations in composition found, and leave it to the judgment of those using the table to determine what figures to choose in their particular case. As this, however, requires an intimacy with the relations between soil and plants, that only a few are in possession of, it is not thought advisable to do so, but only average figures are given.

The quantities of the digestible portion of each fodder, as determined by numerous digestion experiments, are also given below. The figures in the table giving the composition of the fodders are the averages taken from Dr. E. A. Jenkins' compilation of American fodders in the Connecticut Agricultural Experiment Station Report for 1888, and the percentages of digestible matter are calculated from the coefficients of digestibility given in the report for 1886, from the same Station.

The *nutritive ratio* is the proportion of digestible protein to digestible carbhydrates and fat in a ration, the percentage of fat being multiplied by 2.2 and added to the carbhydrates, as one pound of fat produces 2.2 times as much heat when burnt as fuel, as does a pound of carbhydrates.

Table I. Average Composition of American Feeding Stuffs.

FEEDING STUFFS.	No. of analyses.	PERCENTAGE COMPOSITION.						PER CENT. OF DIGESTIBLE MATTER.			Nutritive Ratio, 1:
		Water.	Ash.	Crude protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.	Crude protein.	Carbhydrates.	Ether extract.	
Pasture grass	....	80.0	2.0	3.5	4.0	9.7	0.8	2.6	10.6	0.5	4.5
Green fodder corn (maize)	75	78.7	1.1	1.8	5.0	12.9	0.5	1.3	12.2	0.4	10.1
Corn ensilage,	59	80.3	1.5	1.3	5.7	10.5	0.7	0.8	10.2	0.6	14.4
Clover ensilage	3	76.3	2.5	3.3	6.7	10.2	1.0	2.2	11.0	0.6	5.6
Clover hay	33	11.4	6.2	12.6	26.9	40.6	2.4	6.9	38.5	1.2	6.0
Timothy hay	55	10.2	4.2	6.2	30.3	47.0	2.1	3.5	46.8	1.0	14.0
Hay from mixed meadow grasses	11	16.0	4.6	6.4	29.9	41.0	2.1	3.6	42.7	1.0	12.5
Millet hay	....	16.7	5.8	5.9	28.1	42.1	1.4	3.4	42.4	0.7	12.9
Corn fodder—field cured	13	24.4	4.5	5.3	24.2	40.1	1.5	2.7	40.5	0.9	15.7
Oat straw	12	8.7	5.2	3.8	41.5	38.9	2.2	1.6	42.8	0.7	27.7
Rye straw	8	7.7	3.8	3.5	45.3	38.4	1.4	0.7	41.4	0.4	60.4
Wheat straw	6	8.8	4.2	3.5	45.0	37.3	1.3	0.6	43.8	0.5	74.8
Mangolds	8	90.4	1.0	1.4	0.9	6.1	0.2	1.1	5.8	....	5.3
Rutabagas	3	87.5	1.2	1.3	1.3	8.5	0.2	0.7	7.6	....	10.9
Turnips	3	90.4	0.8	1.1	1.2	6.3	0.2	0.6	5.6	....	9.3
Potatoes	1	78.1	0.9	2.2	0.5	18.2	0.1	1.4	17.2	....	12.3
Barley	9	10.9	2.4	12.4	2.6	69.9	1.9	9.7	68.2	1.3	6.8
Oats	25	10.9	3.0	11.4	9.9	60.1	4.8	9.5	44.4	3.9	5.6
Rye	6	11.6	1.9	10.6	1.6	72.6	1.7	8.3	65.5	1.2	8.3
Wheat	310	10.5	1.9	11.8	1.8	71.9	2.1	9.2	64.9	1.4	7.4
Corn (maize)	192	10.5	1.5	10.6	2.1	69.9	5.5	8.4	64.9	4.7	9.0
Pea meal	2	10.5	2.6	20.2	14.3	51.2	1.2	18.0	56.0	0.9	3.2
Sorghum seed	9	12.5	1.8	8.9	1.9	71.3	3.7	7.6	68.5	2.8	9.8
Malt sprouts	3	10.3	5.7	23.0	10.7	48.6	1.8	18.9	52.9	0.9	2.9
Brewers' grains	15	75.0	1.0	5.6	3.9	12.9	1.7	4.1	9.8	1.4	3.1
Brewers' grains dried	3	8.2	3.6	19.9	11.0	51.7	5.6	14.5	37.4	4.7	3.3
Cotton seed meal	29	8.3	7.3	42.4	5.7	23.0	13.4	36.0	23.2	11.8	1.4
Oil meal—old process	14	9.2	5.8	32.3	9.1	35.3	8.3	26.5	30.4	7.6	1.8
Oil meal—new process	12	10.7	5.6	32.9	9.5	38.3	3.1	27.0	32.2	2.8	1.4
Rye bran	6	11.5	3.6	15.3	3.5	63.7	2.5	10.1	47.9	1.5	5.1
Wheat bran from roller mills	7	12.0	5.6	16.1	8.4	53.7	4.2	12.6	44.1	2.9	4.0
Wheat bran—old process	9	12.0	4.9	13.0	8.1	58.2	3.8	10.1	47.5	2.6	5.3
Wheat shorts	8	12.7	4.3	13.8	7.5	57.6	4.1	10.8	46.8	2.8	4.9
Wheat middlings	27	12.0	3.3	15.2	4.6	59.9	4.0	11.9	48.5	2.8	4.6
Gluten meal	14	9.3	0.8	29.7	1.6	52.0	6.5	24.3	38.3	6.0	2.1
Corn (maize) bran	1	9.8	1.7	7.1	11.3	65.1	5.0	5.5	54.8	3.5	11.5
Corn (maize) cob	17	10.8	1.3	2.4	30.4	54.6	0.5	1.9	52.1	0.3	27.7

Scientists have been working during a generation to solve the problem of the systematic feeding of farm animals. It was very early discovered that the nitrogenous bodies played an important part in the nutrition of animals, a ration containing a large proportion of these bodies giving the best results, other things being equal. As the outcome of the practical experience gained by long continued, patient investigations, certain feeding standards were constructed, giving quantities of total dry matter, of digestible matter and the proportion of the different nutrients in the latter.

This work has been done almost exclusively by German experimenters, and to these belong the honor of having first brought forward to the light the problem of the nutrition of our farm animals.

Below are given feeding standards for cattle, compiled by the German scientist, Dr. Emil Wolff:

Table II. Feeding Standards.—According to Wolff.

Per day and per 1,000 lbs. Live Weight.

	Total organic substance.	Nutritive (digestible) substances.			Total nutritive substances.	Nutritive ratio.
		Crude protein.	Carbhydrates.	Ether extract.		
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
1. Oxen at rest in stall	17.5	0.7	8.0	0.15	8.85	1:12.
2. Wool sheep, coarser breeds	20.0	1.2	10.3	0.20	11.70	1:9.
Wool sheep, finer breeds	22.5	1.5	11.4	0.25	13.15	1:8.
3. Oxen moderately worked	24.0	1.6	11.3	0.30	13.20	1:7.5
Oxen heavily worked	26.0	2.4	13.2	0.50	16.10	1.6.
4. Horses moderately worked	22.5	1.8	11.2	0.60	13.60	1:7.0
Horses heavily worked	25.5	2.8	13.4	0.80	17.00	1:5.5
5. Milch cows	24.0	2.5	12.5	0.40	15.40	1:5.4
6. Fattening oxen, 1st period	27.0	2.5	15.0	0.50	18.00	1:6.5
Fattening oxen, 2d period	26.0	3.0	14.8	0.70	18.50	1:5.5
Fattening oxen, 3d period	25.0	2.7	14.8	0.60	18.10	1:6.0
7. Fattening sheep, 1st period	26.0	3.0	15.2	0.50	18.70	1:5.5
Fattening sheep, 2d period	25.0	3.5	14.4	0.60	18.50	1:4.5
8. Fattening swine, 1st period	36.0	5.0	27.5		32.50	1:5.5
Fattening swine, 2d period	31.0	4.0	24.0		28.00	1:6.0
Fattening swine, 3d period	23.5	2.7	17.5		20.20	1:6.5
9. Growing cattle:						
Age, Months. — *Average live weight, per head.*						
2—3 — 150 lbs	22.0	4.0	13.8	2.0	19.8	1:4.7
3—6 — 300 lbs	23.4	3.2	13.5	1.0	17.7	1:5.0
6—12 — 500 lbs	24.0	2.5	13.5	0.6	16.6	1:6.0
12—18 — 700 lbs	24.0	2.0	13.0	0.4	15.4	1:7.0
18—24 — 850 lbs	24.0	1.6	12.0	0.3	13.9	1:8.0
10. Growing sheep:						
5—6 — 56 lbs	28.0	3.2	15.6	0.8	19.6	1:5.5
6—8 — 67 lbs	25.0	2.7	13.3	0.6	16.6	1:5.5
8—11 — 75 lbs	23.0	2.1	11.4	0.5	14.0	1:6.0
11—15 — 82 lbs	22.5	1.7	10.9	0.4	13.0	1:7.0
15—20 — 85 lbs	22.0	1.4	10.4	0.3	12.1	1:8.0
11. Growing fat pigs:						
2—3 — 50 lbs	42.0	7.5	30.0		37.5	1:4.0
3—5 — 100 lbs	34.0	5.0	25.0		30.0	1:5.0
5—6 — 125 lbs	31.5	4.3	23.7		28.0	1:5.0
6—8 — 170 lbs	27.0	3.4	20.4		23.8	1:6.0
8—12 — 250 lbs	21.0	2.5	16.2		18.7	1:6.5

An example will readily explain the manner in which the above tables are to be used. Supposing we have at our disposal the following common feeding stuffs: corn fodder, clover hay, and bran, and that we wanted to know, how much is required to keep a milch cow of 1,000 lbs. in good condition and to secure a maximum yield of milk. The feeding standard for milch cows calls for 24 lbs. of total organic matter, 2.5 lbs. of digestible protein, 12.5 lbs digestible carbhydrates, etc., and a nutritive ratio of 1:5.4. The composition of the mentioned feeding stuffs will be seen from the table. Organic matter, being what is in the fodder besides water and ash, is found by subtracting the percentages of water and ash from 100. Corn fodder consequently contains 100—(24.4 + 4.5) = 100 — 28.9 = 71.1 per cent. of organic matter and, in the same way, bran (new process) is found to contain 82.4 per cent., and clover hay 82.4 per cent. of organic matter. We will now feed 10 lbs of corn fodder and 6 lbs. of clover hay to start with and add as grain feed, 10 lbs. of bran. According to Table No. 1, these quantities contain the following number of pounds of digestible matter:

	Organic matter.	DIGESTIBLE.		
		Protein.	Carbhydrates.	Ether extract.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
10 lbs. corn fodder	7.11	.27	4.05	.09
6 lbs. clover hay	4.94	.41	2.31	.07
10 lbs. bran	8.24	1.26	4.41	.29
Total	20.29	1.94	10.77	.45

This ration falls short of the feeding standard as regards both total organic matter and digestible substances. To bring it nearer to the standard, we shall have to add a concentrated feed comparatively rich in protein. In selecting the food and deciding the quantities to be given in each case, the market prices naturally must be considered. The concentrated nitrogenous fodders are the most expensive ones, and, as a rule, it does not pay to buy them when bran or oats can be had at reasonable prices. In this case we will suppose, however, that a lot of oil meal is available; we will add two pounds of new process oil meal to the above ration:

	DIGESTIBLE.			
	Organic matter.	Crude protein.	Carbhydrates.	Ether extract.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Ration as above	20.29	1.94	10.77	.45
2 lbs. of oil meal (new process).	1.67	.54	.64	.06
Total	21.96	2.48	11.41	.51
Feeding standard	24.00	2.50	12.50	.40

The ration now corresponds nearly with the feeding standard; there is a deficit in organic matter, but, on the other hand, the digestible substances are present in sufficient quantities, except digestible carbhydrates, of which there is a deficit. The addition of a few pounds of corn fodder would bring these up to the standard. The nutritive ratio is found in this way:

$$.51 \times 2.2 = 1.122;\ 1.122 + 11.41 = 12.532;$$

this number divided by 2.48 (the number of pounds of protein in the ration) gives 5.1; the nutritive ration consequently is as 1:5.1. This ration is somewhat narrower than the standard, but will doubtless render good service. If two pounds of bran were replaced by an equal quantity of corn meal, the ration would come very near the mark.

There is, however, no need of trying to follow the standard blindly. In practical feeding, the ratios for milch cows oftener come above 1 to 6 than below. The eminent German scientist, Dr. Julius Kühn, advocates no definite ratio for milch cows, but says that, according to the conditions present, the lactation, yield, power of production, etc., of the cow, the nutritive ratios may profitably vary between 1:5.5 and 1:8, giving preference, however, to a ratio of 1:6 or 6.5, where Dr. Wolff puts it at 1:5.4. It would seem that the rations fed to milch cows in this state come nearer the ratio of Kühn than Wolff's standard ratio for milch cows.

In constructing rations according to the above feeding standards, several points must be considered besides the chemical composition and the digestibility of the feeding stuffs; the standards cannot be followed directly without regard to the bulk and other properties of the fodders; the ration must not be too bulky and still must contain a sufficient quantity of coarse fodder to keep up the rumination of the fodders, in case of cows and sheep, and to secure a healthy condition of the animals.

Further, chemical analysis of feeding stuffs being of necessity very crude, giving only certain groups of nutritive elements present, does not reveal the inner qualities of a plant as a fodder. For instance, the plant might contain a minute quantity of alkaloids or other poisonous substances, the presence of which chemical analysis, as now generally applied to fodders, does not tell, and the plant as a consequence would not be only valueless as a fodder, but still worse, injurious to the health of the animal. This fact alone will explain why the feeding standards and the information we gather from the composition of the fodders cannot be taken as our only guide in the feeding of our farm animals. Practical experience should go hand in hand with scientific knowledge; when this is the case, the information which may be derived from the above tables cannot help being most valuable to the feeder in aiding him to conduct his business on a rational systematic basis.

EXCHANGES.

The Station takes considerable pride in the fact that it now has on file an almost complete list of the agricultural papers published in the United States, besides some from foreign countries, and some not strictly treating of agriculture. These papers come to the Station in exchange for its reports and bulletins. While of the highest value to those connected with the Station as the expression of agricultural experience and sentiment, they are placed where they can be read and referred to by the agricultural students and others of the University, as well as by visitors. Any one desiring sample copies of any of these papers can secure them upon application to the publishers, at the addresses herewith given.

Our list at this date is as follows:

DOMESTIC EXCHANGES.

New England Farmer, Boston, Mass.
The American Cultivator, Boston, Mass.
New England Homestead, Springfield, Mass.
Farm and Home, Springfield, Mass.
Mirror and Farmer, Manchester, N. H.
Holstein Friesian Register, Brattleboro, Vt.
Connecticut Farmer, Hartford, Conn.
Country Gentleman, Albany, N. Y.
The Husbandman, Elmira, N. Y.
Farmers' Club Journal, Hornellsville, N. Y.
American Dairyman, New York, N. Y.
American Agriculturist, New York, N. Y.
New York, Tribune, New York, N. Y.
American Rural Home, Rochester. N. Y.
Popular Gardening and Fruit Growing, Buffalo, N. Y.
Rural and Poultry World, Syracuse, N. Y.
Weekly Press, Philadelphia, Pa.
National Stockman, Pittsburg, Pa.
Farm Journal, Philadelphia, Pa.
Sugar Beet, Philadelphia, Pa.
Farm and Fireside, Philadelphia, Pa., and Springfield, Ohio.
American Grange Bulletin, Cincinnati, Ohio.
Ohio Farmer, Cleveland, Ohio.
Industrial News, Toledo, Ohio.
American Farm and Horticulturist, Lakewood, Ohio.
Indiana Farmer, Indianapolis, Ind.
Jersey Bulletin, Indianapolis, Ind.
Drainage and Farm Journal, Indianapolis, Ind.
Sorghum Grower's Guide, Madison, Ind.
American Shorthorn Gazette, Indianapolis, Ind.
Breeder's Gazette, Chicago, Ill.
Farm, Field and Stockman, Chicago, Ill.
Prairie Farmer Chicago, Ill.
The Dairy World, Chicago, Ill.
Western Rural, Chicago, Ill.
Farmer's Review, Chicago, Ill.
United States Miller, Chicago and Milwaukee, Wis.
Der Deutsch-Amerikanische Müller, Chicago, Ill., and New York City.
Orange Judd Farmer, Chicago, Ill.
The Western Swineherd, Genesseo, Ill.
The Western Plowman, Moline, Ill.
Wool Journal, Chicago, Ill.
Northwestern Agriculturist, Minneapolis. Minn.
Farm, Stock and Home, Minneapolis, Minn.

The Homestead, Des Moines, Iowa.
The Western Farmer and Stockman, Sioux City, Iowa.
Colman's Rural World, St. Louis, Mo.
The Farmer's Call, Quincy, Ill., and St. Louis, Mo.
Southern Live Stock Journal, Starkville, Miss.
Kansas Farmer, Topeka, Kan.
Industrialist, Manhattan, Kan.
Live Stock Indicator, Kansas City, Kan.
Western Resources, Lincoln, Neb.
Nebraska Farmer, Lincoln, Neb.
Pacific Rural Press, San Francisco, Cal.
American Swineherd, Alexandria, Dak.
The North Dakota Farmer, Aberdeen, N. Dak.
The Northwestern Farmer and Breeder, Fargo, N. Dak.
Southern Cultivator, Atlanta, Ga.
The South Illustrated, New Orleans, La.
Home and Farm, Louisville, Ky.
Baltimore Sun, Baltimore, Md.
Montana Livestock Journal, Helena, Mont.
Texas Farm and Ranch, Dallas, Tex.
Western Farmer, Madison, Wis.
Hoard's Dairyman, Fort Atkinson, Wis.
Wisconsin Agriculturist, Racine, Wis.
Lodi Valley News, Lodi, Wis.
Acker und Gartenbau-Zeitung, Milwaukee, Wis.
Manitowoc Tribune, Manitowoc, Wis.
St. Croix Republican, New Richmond, Wis.

FOREIGN EXCHANGES.

Journal of Agriculture, Montreal, Canada.
Canadian Livestock and Farm Journal, Toronto, Canada.
The Northwest Farmer, Winnipeg, Manitoba.
The Maritime Agriculturist, Sackville, N. B.
Bell's Weekly Messenger, London, England.
The Dairy, London, England.
The Analyst, London. England.
The Field, London, England.
Live Stock Journal, London, England
Agricultural Gazette, London, Eng.
North British Agriculturist, Edinburgh, Scotland.
Ulster Agriculturist, Belfast, Ireland.
Landwirthschaftische Wochenblatt, Hamburg, Germany,
Journal für Landwirthschaft, Berlin, Germany.
Milch-Zeitung, Bremen, Germany.
Zeitschrift für Nahrungsmittel-Untersuchung und Hygiene, Vienna, Austria.
Le Messager Agricole, Paris, France.
Bulletin Des Séances de la Société Nationale D'Agriculture de France, Paris, France.
L'Industrie Laitiére, Paris, France.
Kgl. Landtbruks-Akademiens Handlingar och Tidskrift, Stockholm, Sweden.
The Australian Ironmonger, Melbourne, S. Australia.

ACKNOWLEDGMENTS.

The Station is glad to receive seeds or plants of new varieties, and when possible will give the same an impartial trial, announcing the results in its reports. Other articles, as machinery or materials of agricultural interest, will be received and placed among our exhibits: acknowledgment of them in the report and exhibition will be considered as discharging the obligations of the Station to the donors.

In case of articles which appear of sufficient general interest to merit it, appropriate tests will be instituted, provided the other work of the Station will permit, and the results of such tests published for the information of the farmers of the state. In no case, however, will the Station recommend and endorse any such article otherwise than, as above stated, by publishing the results of actual tests.

Department of Agriculture, Washington, D. C., 47 packages vegetable and other seeds.

John A. Salzer, La Crosse, Wis., two and one-eighth bushels White Bonanza Oats.

D. H. Talbot, Sioux City, Iowa, one quart black barley.

H. A. March, Fidalgo, W. T., 2 packets American grown cauliflower seed.

R. Younger, Madison, Wis., samples of Scotch Regent and Scotch Champion potatoes.

S. Frogner, Hermann, Minn., sample Early Minnesota, seedling No. 18, and seedling No. 50 potatoes.

Northrup, Braslan & Goodwin Co., Minneapolis, Minn., packets of several varieties vegetable seeds.

Wm. Gill, Madison, Wis,. 20 lbs. colored salt.

A. M. Nichol, Granville, O., packet Nichol's Stone Tomato seed.

Wm. Andrus, Reedsburg, Wis., one hog trough.

Stephen Hoyt's Sons, New Caanan, Ct., 2 vines Green Mountain grape.

Thomas Crane, Fort Atkinson, Wis., seven varieties potatoes and one of sweet corn.

Nauvoo Fruit Grower's Association, Nauvoo, Ill., one dozen plants Lady Rusk strawberry.

D. A. Ingebretsen, Fort Howard, Wis., sample seed barley.

F. R. Palmer, Mansfield, Ohio, 10 plants Muskingum raspberry.

Charles Carpenter, Kelley's Island, Ohio, 6 plants Erie raspberry.

Jackson Dawson, Arnold Arboretum, Jamaica Plain, Mass., package containing plants of four species of prunus, also bitter almond, and Amelanchiar Canadensis.

Matthew Crawford, Cuyahoga Falls. Ohio, 24 plants Welsh strawberries, 2 plants of Potter grape, and 4 tubers new seedling potato.

H. Sibley & Co., Rochester, N. Y., seeds of a vetch and a chick pea.

C. W. Minott, Burlington, Vt., one pound each of fifty-five varieties of potato.

J. T. Lovett Co., Little Silver, N. J., 24 plants each of Monmouth and Gandy strawberries.

J. M. Smith, Green Bay, Wis., 50 plants Wilson strawberry.

L. H. Bailey, Cornell University, Ithaca, N. Y., 5 cuttings Crandall currant.

E. E. Stein, Cuyahoga Falls, Ohio, samples of 7 varieties of potato.

Cleveland Nursery Co., Lakewood, Ohio, plants of Haverland, Gypsy, Clingto and Clara strawberries, also of Ada, Palmer, Thompson's Early Pride and Thompson's Early Prolific raspberries and Thompson's Early Mammoth blackberry.

F. A. Huebner, Manitowoc, Wis., samples 6 new varieties of potatoes.

A. B. Cleveland Co., New York City, package Cleveland's Colossal Sweet corn.

Delano Moore, Presque Isle, Me., packet American rutabaga seed.

Peter Henderson & Co., New York City, package of corn for seed.

J. O. Nigh, New Castle, Wis., sample of Nigh's Prolific potato; also one-half peck White Defiance oats received in 1888, but overlooked.

FINANCIAL STATEMENT.

The Wisconsin Agricultural Experiment Station, in account with the United States Appropriation.

Page 5. *Dr.*

	Page.	*Cr.*	
1889.			
To receipts from treasurer of the United States, as per appropriation for the year ending June 30, 1889, under act of congress approved March 2, 1887			$15,000 00
By salaries	21	$5,100 00	
Labor	31	5,332 82	
Laboratory supplies	41	972 11	
Farm supplies	51	77 36	
Freight and express	61	173 09	
Postage and office supplies	71	423 26	
Library	81	61 73	
Farm implements	91	189 66	
Apparatus	101	243 43	
Furniture	111	45 00	
Seed and plants	131	18 50	
Live stock	141	289 30	
Feed	151	753 64	
Traveling	161	250 94	
Fuel and light	171	280 34	
Incidental expenses	181	38 88	
Building and repairs	191	749 94	
		$15,000 00	$15,000 00

I hereby certify that the foregoing statement is a true copy from the books of account of the institution named.

E. F. RILEY,
Secretary.

MADISON, Wisconsin, October 25th, 1889.

APPENDIX.

The general reader does not care for the mass of figures which must accumulate in conducting experiments; the critical reader and the specialist desire a pretty full presentation of the data, in order to review the work and observe the basis upon which any conclusions drawn, may rest. Further; as the work advances, by having full data at hand, new facts and results may be discovered, which were not in sight at the time of recording the figures. It seems proper to take as many of the long tables out of the body of the report as possible, and collect them in an appendix. By this isolation it is hoped the body of the report becomes more readable to the general farmer, while the giving of fuller data, which is thereby possible, will be equally satisfactory to the critical reader and specialist.

Table Giving Chemical Composition of Viscera of Hogs in Experiment, reported on page 6.

Lot.	No.	Solids in blood.	MEAT OF SECTION.			MUSCLE.			KIDNEYS.
			Water.	Fat.	Dry lean meat.	Water.	Fat.	Dry lean meat.	Dry matter.
		per ct.	*per ct.*	*per ct.*	*per ct.*	*per ct.*	*per ct.*	*per ct.*	*per ct.*
A......	1	22.08	32.89	57.80	9.31	65.36	8.94	25.75	....
	2	23.01	27.49	63.00	9.51	64.89	11.19	23.92	....
B......	7	27.00	25.97	....	....	71.44	....	....	24.02
	8	24.91	22.31	....	....	70.23	....	....	24.80
Average	......	24.24	27.16	60.40	9.41	67.96	10.06	24.84	24.41
A......	3	24.68	28.52	61.81	9.67	69.89	4.64	25.47	....
	4	22.56	31.39	59.83	8.78	68.58	6.45	24.97	....
B......	9	26.08	24.19	....	....	69.63	....	....	25.24
	10	25.02	29.57	....	....	69.88	....	....	26.36
Average	......	24.58	28.41	60.82	9.23	69.49	5.54	25.22	25.80
A......	5	22.98	27.57	63.60	8.83	69.83	5.39	24.78	....
	6	24.08	19.73	74.01	6.26	67.01	7.82	25.17	....
B......	11	23.96	16.95	....	....	65.85	....	....	27.10
	12	25.37	16.41	....	....	67.11	....	....	25.43
Average	......	24.09	20.16	68.80	7.55	67.45	6.60	24.98	26.26

Table Giving Data of Experiment Reported on Page 6.

FEED.	Lot.	No.	Live wt.	Drs'd wt.	Stomach.	Spleen.	Heart.	Tongue	Lung	Liver	Uterus.	Lard from intestines.	Kidneys.	Length of small intestines.	Length of large intestines.	Blood.	Length of body.	Length of head.	Breaking str'gth of thigh bones.
			Lbs.	*Lbs.*	*Gms.*	*Grams.*	*Grams.*	*Grams.*	*G'ms.*	*G'ms.*	*Grams.*	*Grams.*	*G'ms.*	*Feet.*	*Feet.*	*Grams.*	*Feet.*	*Feet.*	*Lbs.*
One-third dried blood, two-thirds corn meal......	A	1	271.5	232	618.5	102	261	677.5	676	1685.5	467	2399	277	65	15.7	3100.4	4.35	.75	......
		2	288.5	246	673.5	150	286	600	958	1883.5	....	2732	280	61.2	14.8	3542.8	4.65	.85	....
	B	7	296	252	612	167	298	659	897	1375	....	3187	280.5	61.9	13.1	3282	4.5	.87	910
		8	302.5	260.5	658	105	305	610	720	1290	....	3075	258	61.6	13.8	3296	4.6	.90	1000
Average	......	....	289.6	247.6	640.5	131	287.2	636.7	807.7	1558.5	....	2848	273.6	62.4	14.3	3305.3	4.5	.84	955
One-half pea meal one-half corn meal...........	A	3	275.5	237	645	103.5	245	582	984	1587.5	432	2010	230	63	19.	2730.3	4.5	.80	....
		4	250	210	606	76	240	627	1038.5	1300	....	2232.5	203	59.2	16.0	3212.5	....	....	......
	B	9	279.5	239	695	105	316	568	717	1475	....	2372	254	56.1	14	2634	4.5	.87	850
		10	266	226	620	102	252	566	758	1183	....	2309	186	60	16.1	2950	4.2	.85	1300
Average........	......	....	267.7	228	641.5	94.1	263.2	585.5	874.8	1373.8	....	2230.8	218.2	59.8	16.4	2870.2	4.4	.84	1075
Corn meal only...	A	5	224	185.5	583	78	210	582	900	1186	404	1870	156	60	18.2	2280	....	....	....
		6	263.5	227.5	552	68	258	553	1078	1107	....	2208	167	59.8	17.6	2401	4.85	.40	....
	B	11	236	200	553	103	237	505	643	990	440	2170	185	54.8	14.5	2636	4.3	.95	710
		12	272	238	510	86	255	481	650	1040	......	2685	157	57.2	14.6	2276	4.5	.80	790
Average........	......	....	248.8	212.5	537	83.7	241	542.7	817.7	1068.2	......	2255.7	166.7	57.9	16.2	2623	4.51	.72	750

Table Giving Data of Experiment Reported on Page 13.

Lot.	No.	Live weight.	Dressed weight.	Heart.	Lungs.	Blood.	Liver.	Kid-neys.	Spleen.	Stom-ach.	Fat from intes-tines.	Length of small intes-tines.	Length of large intes-tines.	Hair.	Total length of body.	Length of head.	Breaking strength of thigh bones. 1	Breaking strength of thigh bones. 2
		Lbs.	*Lbs.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Feet.*	*Feet.*	*Grams.*	*Feet.*	*Feet.*	*Lbs.*	*Lbs.*
I.........	1	222	186.2	276	474	2565	1447	165	67	585	2357	64.4	17	297	3.2	.75	920	860
	2	142	118	176	480	1260	648	118	52	346	1834	53.2	14	189	3.6	.85	940	840
Total....	......	364	304.2	452	954	3825	2095	283	119	931	4191	117.6	31	486	....	....	3560	
II	1	164	135.7	192	411	1647	1046	106	55	415	1707	54	14	297	3	1.05	620	590
	2	167	138.5	221	412	1793	963	121	52	442	1873	58.4	16.4	405	2.95	.80	330	460
Total....	.. ...	331	274.2	413	823	3440	2009	227	107	857	3580	112.4	30.4	702	....	....	2000	
III... ...	1	173	146.2	216	443	1961	921	139	81	409	2059	50.8	13.7	351	3.1	.77	510	580
	2	128	103	202	354	1289	744	113	59	345	1683	56.3	14.2	243	2.7	.77	300	380
Total....	.. ..	301	249.2	418	797	3250	1665	252	140	754	3742	107.1	27.9	594	....	....	1770	

Table Giving Data of Experiment Reported on Page 15.

Lot.	No.	Live weight.	Dressed weight.	Heart.	Lungs.	Blood.	Liver.	Kidneys.	Spleen.	Uterus.	Tongue	Fat from intestines.	Length of small intestines.	Length of large intestines.	Length of head.	Length of body.	Breaking strength of thigh bones.	
																	1	2
		Lbs.	*Lbs.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Lbs.*	*Lbs.*
I........	1	123.5	99	169	339	1440	664	106	59	....	437	1216	53	14	.75	2.95	780	790
	2	151.5	120	181	359	1751	935	129	78	302	419	2060	55	13	.75	3.1	850	850
Total....	.....	275	219	350	798	3191	1599	235	137	....	856	3282	108	27	....	....	3270	
II........	1	141	113.5	157	367	1459	741	118	67	....	307	1959	53.1	14	.75	3	680	660
	2	132	106	166	311	1520	809	116	57	341	338	1824	56	13.5	.7	3	580	580
Total....	......	273	219.5	323	678	2979	1550	234	124	.... .	645	3783	109.1	27.5	....	....	2500	
III.......	1	128.5	103.7	144	268	1519	770	105	63	96	306	1763	33.9	13.8	.7	2.85	260	270
	2	106	80.5	143	368	1458	721	102	55	124	312	1063	53.3	13.3	.8	2.8	380	310
Total.. .	.....	234.5	184.2	287	636	2977	1491	207	118	....	618	2826	107.2	27.1	....	....	1220	

SUMMARY OF PIG FEEDING TRIALS AT THIS STATION.

All of the more important data relative to the various feeding trials at this Station, are summarized in the following table, which needs but little explanation. The first column contains the kind of food given during the trials, in the second column each experiment is numbered so that it can be located when required.

The "weight at the beginning of the trial" means the aggregate weight of all the animals in that trial, they always being about equal one with another in this regard. The gain is for the whole lot, on trial, as is the amount of food eaten. The last column refers to the printed annual reports of this Station, where the experiment was first described.

Summary of Hog Feeding Trials at this Station.

Kind of feed.	No. of trials.	No. of animals fed.	Weight at beginning of trial.	No. of days of trial.	Gain.	Amo'nt eaten.	Time of year of trial.	Where reported.	
			Lbs.		*Lbs.*	*Lbs.*		*Rep.*	*p.*
Shelled corn	1	2	435	14	45	233	Mar.-Apr.	II	26
	2	3	652	28	92	756	Feb.-Mar.	III	36
	3	3	692	28	90	792	Feb.-Mar.	III	36
	4	3	554	15	16	150	Feb.	IV	63
	5	3	570	15	21	164	Mar.	IV	63
	6	3	487	25	100	480	Winter.	IV	59
	7	2	?	25	27	237	Winter.	IV	59
	8	2	272	56	156	644	Dec.-Feb.	V	89
Corn meal	9	2	105	25	42	169	July.-Aug.	I	33
	10	2	172	25	61	253	Aug.-Sept.	I	33
	11	2	123	18	33	168	Sept.	I	34
	12	3	188	42	104	558	July.-Aug.	III	34
	13	3	616	23	77	432	Jan.	IV	70
	14	3	657	23	85	365	Feb.	IV	70
	15	3	270	136	291	1690	June-Nov.	IV	86
	16	2	146	98	202	942	Dec.-Mar.	V	100
	17	4	874	21	138	700	Feb.-Mar.	I	29
	18	4	946	28	132	685	Mar.-Apr.	I	29
	19	2	191	143	305	1459	Feb.-July.	VI	7
	20	2	204	149	316	1527	Feb.-July.	VI	7
	21	2	129	149	246	1127	July-Dec.	VI	15
	22	2	128	149	210	1106	July-Dec.	VI	15
	23	2	128	149	180	1034	July-Dec.	VI	15
	24	2	128	128	160	855	Winter.	VI	16
	25	2	127	128	158	854	Winter.	VI	16
	26	2	129	128	116	666	Winter.	VI	16
	27	4	620	21	141	600	Dec.-Jan.	I	27
	28	4	673	21	144	648	Jan.-Feb.	I	28
Corn meal cooked.	29	3	597	21	64	400	Jan.	IV	70
	30	3	715	21	78	406	Feb.	IV	70

Summary of Hog Feeding Trials at the Station — Continued.

Kind of feed.	No. of trial.	No. of animals fed.	Weight at beginning of trial.	No. of days of trial.	Gain.	Amt. eaten.	Time of year of trial.	Where reported.	
			Lbs.		Lbs.	Lbs.		Rep.	p.
Barley meal	31	1	[illegible]	[illegible]	[illegible]	[illegible]	Oct.	IV	68
	32	1	[illegible]	[illegible]	[illegible]	[illegible]	Nov.	IV	68
	33	1	[illegible]	[illegible]	[illegible]	[illegible]	Dec.	IV	[illegible]
	34	1	[illegible]	[illegible]	[illegible]	[illegible]	Jan.	IV	[illegible]
Barley meal cooked	35	1	[illegible]	[illegible]	[illegible]	[illegible]	Oct.	IV	[illegible]
	36	1	[illegible]	[illegible]	[illegible]	[illegible]	Nov.	IV	[illegible]
	37	1	[illegible]	[illegible]	71	[illegible]	Dec.	IV	[illegible]
	38	1	[illegible]	[illegible]	[illegible]	[illegible]	Jan.	IV	[illegible]
Shorts	39	3	[illegible]	[illegible]	[illegible]	[illegible]	July–Aug.	III	34
Sweet skimmilk	40	2	[illegible]	[illegible]	[illegible]	[illegible]	July–Aug.	I	33
	41	2	[illegible]	[illegible]	[illegible]	[illegible]	Aug.–Sept.	I	33
Two parts shelled corn and one part shorts	42	3	[illegible]	[illegible]	[illegible]	[illegible]	Jan.–Feb.	III	35
	43	3	[illegible]	[illegible]	[illegible]	[illegible]	Jan.–Feb.	III	35
	44	3	[illegible]	[illegible]	[illegible]	[illegible]	Winter.	III	[illegible]
Two parts corn and one part shorts cooked	45	3	[illegible]	[illegible]	[illegible]	[illegible]	Winter.	III	[illegible]
One part corn and two parts shorts	46	3	[illegible]	[illegible]	[illegible]	[illegible]	Winter.	III	[illegible]
One part corn and two parts shorts cooked	47	3	[illegible]	[illegible]	[illegible]	[illegible]	Winter.	III	[illegible]
Corn meal and shorts, half and half	48	3	155	[illegible]	[illegible]	[illegible]	July–Aug.	III	34
	49	3	[illegible]	[illegible]	[illegible]	[illegible]	Oct.	IV	[illegible]
	50	3	[illegible]	[illegible]	64	[illegible]	Nov.	IV	[illegible]
Corn meal and shorts, half and half, cooked	51	3	430	[illegible]	76	[illegible]	Oct.	IV	[illegible]
	52	3	493	[illegible]	64	[illegible]	Nov.	IV	[illegible]
Corn meal and shorts, half and half, *fed dry*	53	3	343	34	[illegible]	579	Sept.–Oct.	V	95
	54	3	522	34	[illegible]	658	Oct.–Nov.	V	95
	55	2	331	34	63	[illegible]	Sept.–Oct.	V	95
	56	2	[illegible]	34	[illegible]	521	Oct.–Nov.	V	95

Summary of Hog Feeding Trials at the Station— Continued.

Kind of feed.	No. of trial.	No. of anim'ls fed.	Weight at beginning of trial.	No. of days of trial.	Gain.	Amt. eaten.	Time of year of trial.	Where reported.	
			Lbs.		*Lbs.*	*Lbs.*		*Rep.*	*p.*
Corn meal and shorts, half and half, *fed wet*.....	57	3	346	34	165	622	Sept.-Oct.	V	95
	58	3	504	34	172	789	Oct.-Nov.	V	95
	59	2	343	34	111	508	Sept.-Oct.	V	95
	60	2	448	34	109	582	Oct.-Nov.	V	95
One part corn meal and two parts shorts.....	61	2	145	98	162	818	Dec.-Mar.	V	100
Sorghum seed meal *fed wet*..........	62	4	598	21	74	600	Dec.-Jan.	I	27
	63	4	772	21	61	622	Jan.-Feb.	I	28
Sorghum seed meal *fed dry*..........	64	4	826	21	61	552	Feb.-Mar.	I	29
	65	4	1048	28	105	785	Mar.-Apr.	I	29
Corn meal and pea meal, equal parts........ ...	66	2	199	143	338	1562	Feb.-July.	VI	6
	67	2	190	149	381	1660	Feb.-July.	VI	6
Corn meal ⅔, dried blood, ⅓.........	68	2	179	143	395	1611	Feb.-July.	VI	6
	69	2	202	149	415	1705	Feb.-July.	VI	6
Whole oats ⅓, corn meal, ⅔..........	70	3	228	30	71	296	January.	VI	21
	71	3	291	30	76	327	Jan.-Feb.	VI	21
	72	3	376	30	74	390	Feb.-Mar.	VI	21
	73	3	470	31	75	444	April.	VI	21
Whole oats ⅔, corn meal ⅓..........	74	3	218	30	54	282	Dec.-Jan.	VI	21
	75	3	315	30	66	312	Jan.-Feb.	VI	21
	76	3	373	30	69	384	Feb.-Mar.	VI	21
	77	3	497	31	57	410	April.	VI	21
Ground oats ⅓, corn meal ⅔.....	78	3	281	30	102	398	Jan.-Feb.	VI	21
	79	3	227	30	94	377	Dec.-Jan.	VI	21
	80	3	390	30	109	458	Feb.-Mar.	VI	21
	81	3	465	31	152	606	April.	VI	21
Ground oats ⅔, corn meal ⅓.....	82	3	215	30	75	329	Dec.-Jan.	VI	21
	83	3	301	30	83	344	Jan.-Feb.	VI	21
	84	3	368	30	95	410	Feb.-Mar.	VI	21
	85	3	468	31	118	510	April.	VI	21

Summary of Hog Feeding Trials at the Station — **Continued.**

Feed.	No. of trial.	No. of animals fed.	Total weight at beginning.	No. of days of trial.	Gain.	Amount eaten.		Time of year.	Where reported.	
						Grain.	Milk.			
			Lbs.		*Lbs.*	*Lbs.*	*Lbs.*		*Rep.*	*p.*
Corn meal and sweet skimmilk.	86	2	115	18	59	77	402	Sept.	I	34
	87	2	122	18	76	70	733	Sept.	I	34
	88	2	124	18	76	156	257	Sept.	I	34
	89	2	226	25	125	296	1039	June.	I	36
	90	2	300	25	100	148	1485	June.	I	36
	91	3	772	30	176	674	337	Apr.-May.	V	92
	92	3	958	30	154	536	268	June-July.	V	92
	93	2	350	30	104	432	216	Apr.-May.	V	
	94	2	456	30	94	362	181	June-July.	V	
	95	6	732	55	496	1572	4716	Feb.-April.	V	
	96	2	142	98	239	638	1962	Dec.-Mar.	V	100
	97	2	400	63	193	581	2764	Winter.	VI	24
	98	2	144	63	164	286	1680	Winter.	VI	24
Shelled corn and skimmilk.	99	3	785	30	146	704	352	May-June.	V	93
	100	3	953	30	104	497	248	June-July.	V	93
	101	2	330	30	93	306	153	May-June.	V	93
	102	2	446	30	77	308	154	June-July.	V	93
Corn meal and butter milk	103	3	116	135	553	1183	4140	July-Nov.	V	97
	104	3	108	135	494	1229	1117	July-Nov.	V	97
	105	3	108	135	372	1263	421	July-Nov.	V	97
Corn meal and shorts equal parts and sweet skimmilk.	106	3	?	96	430	1445	2890	July-Sept.	IV	24
	107	4	167	46	156	392	916	Oct.-Dec.	VI	26
	108	4	125	42	144	311	832	Oct.-Dec.	VI	27
	109	5	179	30	154	273	835	Oct.-Dec.	VI	29
	110	8	281	28	195	416	877	Oct.-Dec.	VI	28
	111	1 sow 4 pigs	235 9 lbs *	55	160	387	901	Aug.-Oct.	VI	26
	112	1 sow 4 pigs	252 5 lbs *	59	139	401	903	Aug.-Oct.	VI	27
	113	1 sow 9 pigs	214 5½ lbs *	59	243	483	1591	Aug.-Oct.	VI	28
	114	1 sow 6 pigs	235 4½ lbs *	64	160	385	845	Aug.-Oct.	VI	29

* Each.

Summary of Hog Feeding Trials at the Station—Continued.

Feed.	No. of trial.	No. of anim'ls fed.	Total weight at beginning	No. of days of trial.	Gain.	Amount eaten.		Time of year.	Where reported.	
						Grain.	Milk.			
			Lbs.		*Lbs.*	*Lbs.*	*Lbs.*		*Rep.*	*p.*
Corn meal and shorts equal parts, and butter milk......	115	3	?	96	382	1445	2890	July-Sept.	IV	24
Shorts (6 parts), dried blood (1 part), skimmilk (14 parts).	116	3	264	136	405	1651	3302	June-Nov.	IV	86

GENERAL AVERAGES FROM THE FEEDING TRIALS MADE AT THIS STATION.

In the following tables the hogs have been grouped according to weight, the first group containing those weighing less than 50 lbs. at the middle of the feeding trial, the next containing all weighing between 50 and 100 lbs., and so on up to 350 lbs., the maximum weight in any of our trials. In the first column is reference by number to the preceding summary, by means of which each experiment can be located; then comes the number of hogs in each trial, followed by the average weight of the hogs at the middle of the trial. This weight was obtained by adding half of the total gain made during the trial to the total weight of the hogs at the beginning of the trial, and dividing by the number of hogs in the lot. The total days for one hog is obtained by multiplying the number of days in each trial by the number of hogs in the lot. The next two columns, giving the food eaten during the trial and the gain during the trial, need no explanation. In order to use those trials in which milk formed a part of the ration, it was deemed proper to reduce the milk to a standard of dryness comparable with other food articles in the list: to this end the milk was reduced to dry matter, with 15 per cent. water, by multiplying the pounds of milk given by 11.7 per cent. The last column contains a statement of the food required for 100 lbs. of gain, in each trial. The summary of averages is given on page 34 of this report.

Weight of Hogs Under 50 Pounds.

No. of trial.	No. of hogs.	Average weight at outset of trial.	Total days for one hog.	Food eaten during trial.	Gain during trial.	Food for 100 lbs. of gain.
		Lbs.		*Lbs.*	*Lbs.*	*Lbs.*
108	6	45	108	406	144	282
110	6	47	234	711	195	365
Total	12	.	342	1,117	339	.

Weight of Hogs 50-100 Pounds.

No. of trial.	No. of hogs.	Average weight at outset of trial.	Total days for one hog.	Food eaten during trial.	Gain during trial.	Food for 100 lbs. of gain.
		Lbs.		*Lbs.*	*Lbs.*	*Lbs.*
9	2	62	50	174	42	414
11	2	79	36	166	33	504
12	2	90	130	556	104	536
26	2	93	256	660	116	568
29	3	75	126	501	95	527
40	2	65	50	137	50	273
41	2	57	50	136	79	154
45	3	90	125	469	107	438
70	3	95	90	296	71	417
74	3	92	90	492	94	522
79	3	91	90	217	54	401
82	3	54	90	329	75	439
96	2	74	36	124	59	210
97	2	80	36	156	76	205
99	2	81	36	186	76	245
105	3	98	405	1,312	372	352
107	4	61	184	499	156	320
109	5	64	150	371	154	240
Total	48	....	2,027	6,746	1,813	....

Weight of Hogs 100–150 *Pounds.*

No. of trial.	No. of hogs.	Average weight at middle of trial.	Total days for one hog.	Food eaten during trial.	Gain during trial.	Food for 100 pounds of gain.
		Lbs.		*Lbs.*	*Lbs.*	*Lbs.*
10	2	102	50	253	61	402
15	3	138	408	1690	291	580
16	2	123	196	942	202	466
21	2	126	298	1127	246	454
22	2	117	298	1106	210	526
23	2	109	298	1034	180	574
24	2	104	256	855	160	518
25	2	103	256	854	158	515
31	3	140	69	400	85	471
35	3	138	69	392	46	852
49	3	145	69	407	89	457
51	3	149	69	400	76	526
53	3	136	102	570	127	449
57	3	142	102	622	165	377
61	2	113	196	818	162	505
74	3	110	90	327	76	430
72	3	138	90	390	74	527
75	3	116	90	312	66	473
76	3	136	90	384	69	557
78	3	111	90	398	102	390
80	3	148	90	458	109	420
83	3	114	90	344	83	414
84	3	139	90	410	95	432
96	2	131	196	868	239	362
98	2	113	126	483	164	294
108	3	131	405	1667	553	302
04	3	107	405	1360	424	320
Total	71	....	4588	18871	4312	....

Table Giving Data of Experiment Reported on Page 6.

FEED.	Lot.	No.	Live wt.	Drs'd wt.	Stomach.	Spleen.	Heart.	Tongue	Lung	Liver	Uterus.	Lard from intestines.	Kidneys.	Length of small intestines.	Length of large intestines.	Blood.	Length of body.	Length of head.	Breaking str'gth of thigh bones.
			Lbs.	*Lbs.*	*Gms.*	*Grams.*	*Grams.*	*Grams.*	*G'ms.*	*G'ms.*	*Grams.*	*Grams.*	*G'ms.*	*Feet.*	*Feet.*	*Grams.*	*Feet.*	*Feet.*	*Lbs.*
One-third dried blood, two-thirds corn meal.......	A	1	271.5	232	613.5	102	261	677.5	676	1685.5	467	2399	277	65	15.7	3100.4	4.35	.75	....
		2	288.5	246	673.5	150	286	600	958	1883.5	....	2732	326	61.3	14.3	3542.8	4.65	.85	....
	B	7	296	252	612	167	298	659	827	1375	....	3187	239.5	61.9	13.1	3282	4.5	.87	910
		8	302.5	260.5	665	105	305	610	720	1290	....	3075	253	61.6	13.3	3296	4.6	.90	1000
Average	......	....	289.6	247.6	640.5	131	287.2	636.7	807.7	1558.5	....	2848	273.6	62.4	14.3	3305.3	4.5	.84	955
One-half pea meal one-half corn meal...........	A	3	275.5	237	645	103.5	245	582	984	1537.5	432	2010	230	63	19.	2730.3	4.5	.80	....
		4	250	210	606	76	240	627	1038.5	1300	....	2332.5	203	59.2	16.9	3212.5	....	....	....
	B	9	279.5	239	695	105	316	568	717	1475	....	2372	254	56.1	14	2624	4.5	.87	850
		10	266	226	620	102	252	566	758	1183	....	2209	186	60	16.1	2950	4.2	.85	1300
Average........	....	....	267.7	228	641.5	94.1	263.2	585.5	874.3	1373.8	....	2230.8	218.2	59.8	16.4	2879.2	4.4	.84	1075
Corn meal only...	A	5	224	185.5	533	78	219	582	900	1136	404	1870	156	60	18.2	2389	....	....	....
		6	263.5	227.5	552	68	253	553	1078	1107	....	2298	167	59.8	17.6	2491	4.85	.40	....
	B	11	236	200	553	103	237	565	643	990	440	2170	185	54.8	14.5	2636	4.3	.95	710
		12	272	233	510	86	255	481	650	1040	....	2685	157	57.2	14.6	2976	4.5	.80	790
Average........	....	....	248.8	212.5	537	83.7	241	542.7	817.7	1068.2	..... .	2255.7	166.7	57.9	16.2	2623	4.51	.72	750

Table Giving Data of Experiment Reported on Page 13.

Lot.	No.	Live weight.	Dressed weight.	Heart.	Lungs.	Blood.	Liver.	Kidneys.	Spleen.	Stomach.	Fat from intestines.	Length of small intestines.	Length of large intestines.	Hair.	Total length of body.	Length of head.	Breaking strength of thigh bones. 1	Breaking strength of thigh bones. 2
		Lbs.	*Lbs.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Feet.*	*Feet.*	*Grams.*	*Feet.*	*Feet.*	*Lbs.*	*Lbs.*
I..........	1	222	186.2	276	474	2565	1447	165	67	585	2357	64.4	17	297	3.2	.75	920	860
	2	142	118	176	480	1260	648	118	52	346	1834	53.2	14	189	3.6	.85	940	840
Total....	......	364	304.2	452	954	3825	2095	283	119	931	4191	117.6	31	486	....	....	3560	
II	1	164	135.7	192	411	1647	1046	106	55	415	1707	54	14	297	3	1.05	620	590
	2	167	138.5	221	412	1793	963	121	52	442	1873	58.4	16.4	405	2.95	.80	330	460
Total....	.. ...	331	274.2	413	823	3440	2009	227	107	857	3580	112.4	30.4	702	....	....	2000	
III... ...	1	173	146.2	216	443	1961	921	139	81	409	2059	50.8	13.7	351	3.1	.77	510	580
	2	128	103	202	354	1289	744	113	59	345	1683	56.3	14.2	243	2.7	.77	300	380
Total....	.. ..	301	249.2	418	797	3250	1665	252	140	754	3742	107.1	27.9	594	....	....	1770	

Weight of Hogs 250–300 Pounds.

No of trial.	No. of hogs.	Average weight at middle of trial.	Total days for one hog.	Food eaten during trial.	Gain during trial.	Food for 100 lbs. of gain.
		Lbs.		*Lbs.*	*Lbs.*	*Lbs.*
18	4	253	112	685	132	518
30	3	251	63	406	78	521
56	2	258	68	508	98	421
60	2	252	68	532	109	488
65	4	275	112	785	105	747
91	3	287	90	713	176	405
94	2	257	60	383	94	407
99	3	286	90	745	146	510
Total	23	....	663	4760	938	....

Weight of Hogs 300–350 Pounds.

No. of trial.	No. of hogs.	Average weight at middle of trial.	Total days for one hog.	Food eaten during trial.	Gain during trial.	Food for 100 lbs. of gain.
		Lbs.		*Lbs.*	*Lbs.*	*Lbs.*
92	3	345	90	567	154	368
100	3	335	90	526	104	505
Total	6	....	180	1093	258	....

WARM AND COLD WATER EXPERIMENT.

The following tables contain the detail figures of the warm and cold water experiment with milch cows described on pages 146 to 188.

Table 17. Showing the Composition of the Milk for Individual Cows.

Date.	DOLLIE.		JESSIE.		ROSE.		QUEEN.		EMMA.		GOV. HEIFER.	
	Total solids	Fat.	Total solids	Fat.	Total solids	Fat.	Total solids	Fat.	Total solids	Fat.	Total solids	Fat.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
March 1..	14.121	5.235	13.156	4.358	12.314	3.927	12.710	4.584	12.512	4.400	12.094	4.244
2..	13.169	4.800	13.243	4.600	12.084	4.200	12.650	4.800	12.695	4.500	12.173	4.800
3.	14.104	5.386	13.119	4.684	12.561	4.554	13.028	4.857	12.120	4.783	12.985	4.953
4..	13.942	5.149	12.628	4.483	12.046	3.843	12.874	4.545	12.662	4.326	12.635	4.493
5..	13.768	5.509	13.210	5.016	12.494	4.666	12.858	4.884	12.268	4.661	12.624	5.290
6..	14.529	5.318	13.440	4.623	12.847	4.282	12.831	4.459	12.593	4.298	13.132	4.677
7.	13.694	5.114	13.066	4.606	11.907	3.934	12.150	4.394	12.054	4.285	12.557	4.413
8..	13.732	5.359	13.046	4.564	12.689	4.258	12.369	4.452	12.500	4.217	12.652	4.211
9..	14.790	5.753	14.087	4.975	13.154	4.149	13.014	4.634	12.849	4.479	12.419	4.397
10..	14.328	5.323	13.628	4.795	12.575	4.059	12.638	4.480	12.465	4 370	12.457	4.520
11..	13.988	5.321	13.856	5.069	13.369	4.869	12.717	4.646	13.120	4.472	12.634	4.497
12..	13.911	5.162	13.419	4.801	12.512	4.311	12.842	4.521	12.862	4.153	12.640	4.494
13..	13.726	4 792	13.392	4.435	12.029	3.889	12.369	4.356	12.162	4.083	12.096	4.371
14..	14.172	5.225	13.299	4.564	12.708	4.218	13.467	4.568	12.681	4.292	13.614	4.820
15..	13.217	4.795	12.796	4.499	11.853	4.085	12.173	4.332	12.125	4.337	11.981	3.916
16..	13.617	4.789	12.851	4.691	12.952	4.196	12.683	4.420	12.171	4.222	12.594	4.074
17..	14.014	5.038	12.690	4.539	12.315	3.761	12 557	4.243	12.011	3.800	12 551	4 062
18..	13.401	4.675	13.236	4.367	12.579	4.104	12.964	4.260	12.503	4.137	12.837	4.216
19..	14.197	4.976	13.163	4.520	11.955	3.680	12.320	4.165	12.151	4.027	12.555	4.239
20..	13.922	4.824	13.468	4.398	12.344	3.862	12.591	4.524	12.400	4.107	12.689	4.260
21..	14.189	4.775	13.409	4.398	12.486	3.852	12.988	4.535	12.493	4.060	12.867	4.384
22..	14.136	4.818	13.283	4.456	13.051	4.475	13.442	4.645	12.729	4.004	13.139	4.263
23..	14.333	5.054	13.312	4.461	12.401	3.961	13.139	4.606	12.881	4.078	13.052	4.483
24..	13.880	4.856	12.943	4.124	12.709	4.073	12.754	4.367	12.260	3.791	12.986	4.429
25..	13.546	4.789	13.138	4.547	12.214	4.198	12.985	4.642	12.422	4.164	13.431	4.652

Table 18. Showing the Daily Milk Yield.

	COLD WATER.									WARM WATER.								
Period 1.	P. M.	A. M.	Sum.	P. M.	A. M.	Sum.	P. M.	A. M.	Sum.	P. M.	A. M.	Sum.	P. M.	A. M.	Sum.	P. M.	A. M.	Sum.
	Dollie.			Jessie.			Rose.			Queen.			Emma.			Gov. Heifer.		
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Jan. 25..	5.6	6.8	12.4	8.5	8.6	17.1	8.5	11.3	19.8	9.8	12.0	21.8	8.0	9.0	17.0	9.1	10.8	19.9
26..	6.2	6.9	13.1	7.9	9.7	17.6	9.1	10.9	20.0	11.1	11.7	22.8	8.2	8.8	17.0	10.5	11.2	21.7
27..	5.9	7.1	13.0	9.0	9.8	18.8	9.4	10.4	19.8	10.0	12.0	22.0	8.3	9.4	17.7	9.3	11.3	20.6
28..	5.9	7.1	13.0	9.3	9.8	19.1	8.6	10.4	19.0	10.0	11.6	21.6	7.5	9.8	17.3	8.8	12.0	20.8
29..	6.0	6.6	12.6	8.8	9.7	18.5	8.5	11.0	19.5	10.0	11.6	21.6	7.8	9.4	17.2	8.8	10.1	18.9
30..	6.2	7.3	13.5	8.4	9.7	18.1	9.2	11.0	20.2	10.1	11.4	21.5	8.0	9.2	17.2	9.5	11.4	20.9
31..	5.9	6.4	12.3	7.8	8.9	16.7	7.9	10.8	18.7	9.3	11.6	20.9	7.6	9.8	17.4	8.0	11.1	19.1
Feb. 1..	5.2	6.8	12.0	9.0	9.0	18.0	8.0	10.2	18.2	10.6	11.5	22.1	7.2	8.8	16.0	8.5	10.0	18.5
2..	5.7	6.6	12.3	8.5	9.5	18.0	8.9	10.2	19.1	10.0	11.6	21.6	7.0	8.4	15.4	8.3	9.7	18.0
3..	5.1	6.8	11.9	8.4	8.9	17.3	8.6	9.6	18.2	9.8	11.6	21.4	6.5	9.0	15.5	8.9	10.9	19.8
4..	4.9	6.4	11.3	8.2	9.2	17.4	9.1	10.0	19.1	10.2	11.0	21.2	6.8	8.1	14.9	9.2	10.2	19.4
5..	5.4	6.4	11.8	8.5	8.4	16.9	8.4	9.8	18.2	9.6	11.4	21.0	6.8	8.2	15.0	8.2	9.5	17.7
6..	5.2	4.8	10.0	7.9	7.4	15.3	8.9	9.6	18.5	9.9	10.4	20.3	6.6	7.4	14.0	7.6	8.5	16.1
7..	4.0	4.3	8.3	6.8	6.7	13.5	8.7	9.2	17.9	9.2	11.0	20.2	6.8	7.4	14.2	7.8	8.3	16.1
8..	3.4	3.6	7.0	6.0	6.6	12.6	7.3	8.0	15.3	9.4	9.2	18.6	6.1	7.7	13.8	7.0	8.1	15.1
9..	3.2	3.2	6.4	6.8	6.3	13.1	6.4	8.3	14.7	8.3	8.8	17.1	7.1	7.2	14.3	6.5	7.7	14.2
Sums..	83.8	97.1	180.9	129.8	138.2	268.0	135.5	160.7	296.2	157.3	178.4	335.7	116.3	137.6	253.9	136.1	160.8	296.9
Period II	Queen.			Emma			Gov. Heifer.			Dollie.			Jessie.			Rose.		
Feb. 18..	8.3	10.4	18.7	6.2	7.7	13.9	7.9	8.9	16.8	4.8	6.1	10.9	8.0	7.2	15.2	8.8	9.8	18.6
19..	7.9	9.5	17.4	6.5	7.2	13.7	6.6	8.7	15.3	5.2	6.2	11.4	7.9	7.9	15.8	9.0	10.6	19.6
20..	8.1	10.1	18.2	6.4	7.6	14.0	7.0	8.8	15.8	5.8	6.2	12.0	7.7	7.6	15.3	9.4	11.0	20.4
21..	7.9	10.1	18.0	6.3	7.1	13.4	7.3	8.6	15.9	5.7	6.0	11.7	7.9	7.8	15.7	9.5	10.2	19.7
22..	8.9	9.6	18.5	5.8	7.5	13.3	7.8	8.6	16.4	5.9	6.4	12.3	8.3	7.3	15.6	9.1	10.0	19.1
23..	8.1	9.2	17.3	6.3	7.6	13.9	7.4	9.1	16.5	6.0	6.8	12.8	7.4	8.0	15.4	8.8	9.5	18.3

24..	7.8	10.1	17.9	6.6	8.2	14.8	6.8	8.9	15.7	5.8	6.8	12.6	7.5	8.6	16.1	9.1	10.2	19.3
25..	8.1	10.1	18.2	6.7	8.1	14.8	7.8	8.6	16.4	5.3	6.2	11.5	7.6	8.1	15.7	8.5	10.6	19.1
26..	8.5	9.5	18.0	6.5	7.9	14.4	7.3	8.1	15.4	5.5	5.7	11.2	7.0	7.6	14.6	8.8	10.3	19.1
27..	8.8	9.8	18.6	6.6	7.6	14.2	7.4	8.1	15.5	6.3	6.4	12.7	7.2	7.3	14.5	8.7	10.6	19.3
28..	8.7	10.5	19.2	5.9	8.1	14.0	7.4	8.1	15.5	5.3	5.9	11.2	7.4	8.3	15.7	9.0	9.9	18.9
Mch. 1..	9.2	10.7	19.9	5.8	7.2	13.0	7.8	8.8	16.6	5.3	5.8	11.1	7.3	8.1	15.4	9.0	8.5	17.5
2..	9.0	10.2	19.2	6.4	7.7	14.1	8.1	7.7	15.8	5.5	6.7	12.2	8.3	8.0	16.3	9.8	9.3	19.1
3..	8.9	10.3	19.2	6.9	8.0	14.9	7.4	8.6	16 0	5.2	6.4	11.6	8.1	8.0	16.1	9.4	9.0	18.4
4..	8.7	10.3	19.0	6.6	8.2	14.8	6.7	7.9	14.6	5.4	6.4	11.8	8.0	8.3	16.3	9.6	10.3	19.9
5..	8.7	10.3	19.0	7.0	7.6	14.6	8.0	8.3	16.3	5.2	5.9	11.1	7.4	8.3	15.7	8.8	9.8	18.6
Sums..	135.6	160.7	296.3	102.5	123.3	225.8	118 7	185.8	254.5	88.2	99.9	188.1	123.0	126.4	249.4	145.3	159.6	304.9

Period III.	Dollie.			Jessie.			Rose.			Queen.			Emma.			Gov. Heifer.		
March 10	4.3	6.3	10.6	6.7	6.6	13.3	8.7	7.8	16.5	9.2	10.9	20.1	7.0	8.1	15.1	7.6	7.6	15.2
11	5.1	6.4	11.5	7.4	7.7	15.1	5.7	7.1	12.8	9.1	10.6	19.7	6.9	8.3	15.2	7.5	8.8	16.3
12	5.1	6.3	11.4	7.5	7.5	15.0	5.9	7.3	13.2	9.1	10.7	19.8	6.8	7.7	14.0	7.2	8.7	15.9
13	5.9	6.3	12.2	7.7	7.4	15.1	6.6	7.4	14.0	9.6	10.6	20.2	6.5	7.6	14.1	8.0	9.3	17.3
14	5.7	6.4	12.1	8.0	6.8	14.8	7.0	7.8	14.8	9.3	9.6	18.9	6.6	7.6	14.2	7.7	7.6	15.3
15	5.4	6.0	11.4	7.3	7.4	14.7	6.4	8.0	14.4	8.7	11.1	19.8	5.8	8.8	14.6	6.7	9.1	15.8
16	5.2	6.2	11.4	7.9	7.6	15.5	8.0	7.0	15.0	8.8	10.6	19.4	5.8	7.5	13.3	7.9	9.1	17.0
17	5.6	6.7	12.3	7.4	8.0	15.4	8.8	9.3	18.1	9.6	11.2	20.8	6.6	8.4	15.0	7.9	8.9	16.8
18	5.4	6.6	12.0	7.6	7.3	14.9	8.1	9.4	17.5	8.6	10.9	19.5	6.6	8.2	14.8	7.6	9.1	16.7
19	5.8	6.4	12.2	7.6	7.5	15.1	7.9	9.3	17.2	9 3	10.6	19.9	6.4	7.9	14.3	7.5	9.0	16.5
20	5.4	6.2	11.6	7.4	7.9	15.3	8.4	8.3	16.7	9.8	10.0	19.8	7.1	7.4	11.5	8.0	8.4	16.4
21	5.6	6.3	11.9	7.4	7.6	15.0	8.5	8.6	17.1	8.9	10.5	19.4	6.8	8.2	15.0	7.5	9.1	16.6
22	5.6	6.2	11.8	7.1	7.2	14.3	8.7	8.1	16.8	8.2	10.0	18.2	6.0	7.6	13.6	7.3	8.0	15.3
23	5.2	6.2	11.4	7.8	7.8	15.6	7.9	8.3	16.2	8.5	9.6	18.1	6.4	7.1	13.5	7.7	8.5	16.2
24	5.2	6.0	11.2	7.3	6.5	13.8	7.9	8.2	16.1	8.3	10.6	18.9	6.3	7.6	13.9	7.1	9 0	16.1
25	6.0	5.7	11.7	8.4	7.8	16.2	7.8	8.2	16.0	8.8	9.5	18.3	6.1	7.6	13.7	7.0	7.6	14.6
Sums.	86.5	100.2	196.7	120.5	118.6	239.1	122.3	130.1	252.4	143.8	167.0	310.8	103.2	125.6	228.8	120.2	137.8	258.0

Table 19, *showing Composition of the Milk.*

	COLD WATER.			WARM WATER.		
	TOTAL SOLIDS.	SOLIDS NOT FAT.	FAT.	TOTAL SOLIDS.	SOLIDS NOT FAT.	FAT.
PERIOD I.	Dollie, Jessie, Rose.			Queen, Emma, Gov. Heifer.		
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
January 25......	13.305	8.743	4.562	13 890	8.610	4.780
26......	13.330	8.750	4.580	12.960	8.320	4.640
27......	13.590	8.760	4.830	13.089	8.624	4.465
28......	13.750	8.897	4.853	13.154	8.549	4.605
29......	13.467	8.807	4.660	13.247	8.577	4.670
30......	13.534	9.034	4.500	13.086	8.531	4.555
31......	13.436	8.901	4.535	12.927	8.464	4.463
February 1......	13.623	8.828	4.795	13.119	8.731	4.388
2......	13.064	8.575	4.489	12.675	8.190	4.485
3......	13.272	8.663	4.609	12.742	8.255	4.487
4......	13 167	8.671	4.496	12.576	8.535	4.041
5......	13.679	9.067	4 612	13.568	8.829	4.739
6......	13.051	8.296	4.755	12.629	8.071	4.558
7......	13.388	8.607	4.781	12.822	7.923	4.399
8......	13.917	8.775	5.142	12.982	8.428	4.554
9......	13.480	8.517	4.963	12.762	8.149	4.613
Average......	13.441	8.743	4.697	12.951	8.424	4.527
PERIOD II.	Queen, Emma, Gov. Heifer.			Dollie, Jessie, Rose.		
February 18.....	12.452	8.288	4.164	13.057	8.722	4.335
19......	12.817	8.482	4.335	13.457	8.838	4.619
20	12.723	8.326	4.397	13.194	8.605	4.589
21......	12.786	8.228	4.558	12.994	8.515	4.480
22......	12.869	8.393	4.476	13.143	8.948	4.195
23......	13.138	8.549	4.589	13.106	8.537	4.569
24......	13.255	8.678	4.577	13.509	8.857	4.652
25......	13.647	8.746	4.901	13.543	8.738	4.805
26......	12.961	8.329	4.632	13.053	8.542	4.511
27......	12.723	8.354	4.369	13.427	8.761	4.666
28......	12.717	8.276	4.441	13.293	8.591	4.702
March 1......	12.438	8.029	4.409	13.197	8.690	4.507
2......	12.509	7.809	4.700	12.832	8.366	4.466
3......	12.711	7.847	4.864	13 309	8.435	4 874
4......	12.724	8.269	4.455	12.872	8.380	4.492
5......	12.583	8.117	4.466	13.157	8.541	4.616
Average......	12.816	8.295	4.521	13.196	8.629	4.567
PERIOD III.	Dollie, Jessie, Rose.			Queen, Emma, Gov. Heifer.		
March 10..........	13.510	8.784	4.726	12.520	8.064	4.456
11..........	13.737	8.651	5.086	12.823	8.285	4.538
12..........	13.281	8.523	4.758	12.781	8.392	4.389
13..........	13.049	8.677	4.372	12.209	7.939	4.270
14..........	13.393	9.175	4.218	13.254	8.694	4.560
15..........	12.622	8.163	4.459	12.093	7.756	4.337
16..........	13.140	8.581	4.559	12.482	8.243	4.239
17..........	13.006	8.562	4.444	12.373	8.338	4.035
18..........	13.072	8.690	4.382	12.778	8.574	4.204
19..........	13.105	8.713	4.392	12.342	8.198	4.144
20..........	13.245	8.884	4.361	12.560	8.263	4.297
21.........	13.361	9.019	4.342	12.783	8.457	4.326
22..........	13.486	8.903	4.583	13.103	8.799	4.304
23..........	13.348	8.856	4.492	13.024	8.635	4.389
24..........	13.177	8.826	4.351	12.669	8.473	4.196
25..........	12.980	8.485	4.495	12.946	8.460	4.486
Average	13.219	8.718	4.501	12.671	8.348	4.322

Table 20, showing Water and Corn Fodder Consumed Daily.

	COLD WATER.			CORN FODDER	WARM WATER.			CORN FODDER
PERIOD I.	Dollie.	Jessie.	Rose.	D. J. R.	Queen.	Emma.	Gov.'s Heifer.	Q. E. G. H.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
January 25....	62.75	71.50	60.25	35.50	89.50	86.00	76.50	38.50
26....	66.00	73.00	53.00	42.75	74.50	102.00	51.50	48.50
27....	54.00	56.00	49.50	35.50	67.50	69.00	47.50	31.00
28....	71.50	66.50	70.00	40.50	73.50	93.00	74.25	40.00
29....	55.25	70.50	68.25	33.00	89.00	91.50	54.25	30.00
30....	71.25	60.00	72.75	47.60	74.00	71.00	87.50	49.10
31....	57.00	65.50	61.00	36.00	83.00	91.00	55.50	36.25
February 1....	73.50	69.00	70.50	33.50	76.50	88.00	16.00	34.00
2...	37.50	79.50	72.50	30.25	89.00	68.00	97.25	36.75
3....	83.50	58.00	59.00	30.75	86.50	93.50	71.50	33.00
4....	39.50	69.50	61.25	35.25	70.50	64.00	46.50	35.25
5 ...	61.00	66.00	61.00	31.50	88.00	92.00	84.50	28.00
6....	49.00	69.00	72.50	21.25	71.50	70.75	52.00	23.75
7....	47.50	58.75	54.50	23.00	84 50	85.25	60.75	31.00
8....	29.00	66.00	50.75	19.50	51.75	80.75	57.25	25.75
9....	43.25	72.25	71.50	21.00	67.00	68.25	57.75	28.25
Sums......	895.50	1071.00	1008.25	516.85	1236.25	1314.00	990.50	549.10
PERIOD II.	Queen.	Emma.	Gov.'s heifer.	Q. E. G. H.	Dollie.	Jessie.	Rose.	D. J. R.
February 18...	71.50	77.00	61.00	29.00	59.00	62.00	61.00	39.00
19...	62.50	68.50	68.50	41.25	64.50	97.00	101.00	38.50
20...	66.00	61.50	64.50	30.75	65.50	57.50	61.00	33.35
21...	69.00	47.00	55.00	33.50	73.00	89.50	87.25	33.25
22...	53.50	91.50	69.00	35.50	65.50	55.00	65.00	43.50
23...	54.50	57.00	46.25	40.00	71.25	80.75	68.00	41.25
24...	79.75	75.00	59.50	34.50	73.00	74.50	78.75	30.00
25.	9.50	22.50	58.50	35.75	68.00	72.00	82.00	35.50
26...	72.50	75.75	55.50	30.50	64.50	89.00	67.00	34.25
27...	77.00	71.50	38.50	25.75	71.00	63.00	80.00	16.50
28...	74.00	48.00	81.00	33.25	60.25	79.00	67.25	38.75
March 1...	70.00	66.00	63.00	31.25	75.00	69.50	60.50	38.75
2...	55.50	69.00	87.00	36.25	78.00	87.00	83.50	33.25
3...	67.00	76.00	55.75	30.75	79.25	58.00	59.00	32.25
4...	71.25	59.25	58.00	26.75	75.50	82.50	76.00	24.50
5...	76.00	72.00	82.25	36.50	74.50	75.00	82.00	44.00
Sums......	1029.50	1037.50	953.25	531.25	1121.75	1191.25	1179.25	556.50
PERIOD III.	Dollie.	Jessie.	Rose.	D. J. R.	Queen.	Emma.	Gov.'s Heifer.	Q. E. G. H.
March 10.......	68.00	66.50	72.50	23.75	89.50	74.00	78.50	33.25
11.......	63.00	69.00	36.50	25.50	62.50	51.50	52.00	34.50
12.......	74.00	76.00	38.50	22.75	91.00	62.00	72.50	36.25
13.......	71.00	76.50	60.00	26.50	82.00	109.00	76.00	32.50
14.......	66.00	59 00	40.00	32.00	58.00	64.00	40.00	37.25
15.......	70.00	72.00	78.50	24.00	100.50	107.50	89 00	27.25
16.......	60.50	66.00	33.00	34.50	68.50	72.00	54.00	34.50
17.....	68.00	67.00	73.00	39.50	88.50	97.00	74.50	41.50
18.......	68.00	59.75	62.25	28.00	76.00	74.50	59.00	26.00
19.......	56.50	78.50	66.00	29.50	89.00	82.25	76.00	30.75
20.......	74.25	63.25	58.50	27.50	75.00	86.00	61.00	31.50
21.......	60.00	55.25	68.25	32.00	62.00	70.00	58.00	32.00
22.......	63.00	65.50	56.50	31.50	60.50	79.50	48.50	33.00
23.......	49.00	68.50	75.00	30.75	78.50	60.50	54.00	29.75
24.......	82.00	70.00	54.00	31.00	91.00	92.00	82.00	31.50
25.......	60.00	69.00	78.50	25.00	60.50	75.00	52.00	32.00
Sums........	1053.25	1081.75	952.00	463.75	1233.00	1256.75	1027.00	523.50

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